Commercial Evaluation of the Impact of BBC Children's Channels

A study for SCBG

12 October 2004

Introduction

DGA has been commissioned by the Satellite and Cable Broadcasters Group (SCBG) to perform a more detailed version of the structural break analysis outlined in subsection 1.2, Section B, of our report for Nickelodeon, Review of the BBC Digital Children's Channels, which was completed in February 2004.

In this report we performed a preliminary structural break test on a three-year (2001-2003) monthly time-series of children's commercial impacts for the main commercial pay-TV rivals of the BBC digital children's channels (CBBC and CBeebies) and concluded that:

> "…there was conclusive evidence of significant structural break in early 2002, with the break representing a substantial downturn in the growth of commercial impacts relative to the previous trend. Comparing a forward projection of the pre-break trend with the actual post-break commercial impacts suggests that, to date, the aforementioned channels may have lost as many as 20 million commercial impacts (which equates to a revenue in the region of £80 million) as a result of the structural break in early 2002.
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> As early 2002 also marked the advent of CBBC and CBeebies, it is logical to assume that this was a contributing factor to the structural break observed in the actual data. However, given such contemporaneous events as the collapse of ITV Digital, as well as the possible launch of other new commercial digital children's channels, it is much more difficult to say just how much of this downturn in the growth of commercial impacts can be attributed to the BBC's digital children's service.
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> Indeed, while the structural break analysis can be used to identify and test the significance of underlying structural changes in monthly commercial impacts or audiences, both by channel and at aggregate level, and even provide estimates of the resulting losses, a more sophisticated analysis is needed to determine what proportion of these losses may be attributed to a very specific event like the launch of CBeebies and CBBC. [*Review of the BBC Digital Children's Channels*, p. 30]

It is important to stress that the estimate of a potential loss of "as many as 20 million impacts" was a preliminary figure intended only to give a very rough guide to the potential maximum loss, based on a simple linear projection of the pre-break trend of a single variable model, with Time being the only explanatory variable.

As such, a number of important points have subsequently been raised that need to be addressed in a more robust version of the model, which will provide a much better understanding of the actual range of potential revenue loss that may be attributed to the advent of the BBC digital children's channels.

The first point raised was that the model needs to take account of the BARB panel adjustments in January 2002, which led to a significant underestimate of the multichannel audience and were not rectified until May 2002. Although this audience measurement error by BARB did lead to an actual loss and was therefore a part of the aggregate estimate of potential maximum loss due to events in early 2002, it is something that must be accounted for, and its effects excluded from the final figures, when trying to isolate the impact of the BBC digital children's channels on their commercial pay-TV rivals. Indeed, within this context, an event like the BARB measurement error no longer constitutes a structural break but a step change, whose effects, although very real, must be removed from any potential loss calculations. Since the basic single variable linear structure of our original model does not allow us to distinguish between simple step changes and complex structural shocks, what is needed is a model sophisticated enough to allow us to account for any temporary shocks, like the BARB panel effect, which do not affect the long term growth trend, and structural ones, like the advent of the BBC digital children's channels, which do. As will be seen in the analysis below, by incorporating audience factors as explanatory regressors, our new model fully meets this aim and effectively removes the loss caused by the BARB measurement error from the final loss calculations.

The second point raised was the issue of advertising elasticity, whereby a percentage drop in impacts would translate into a smaller percentage fall in revenue due to an upward movement in price (i.e. cost per thousand). Our initial model took market trading information and reflected the fact that the kids' pay-TV channels were price takers in the short to medium term, and so a drop in their impacts would not raise prices. As a result, the majority of their inventory is traded on a fixed CPT, hence we still feel this results in a good approximation of revenue loss, but to further enhance the robustness of our results we now use monthly cost-per-thousand figures, rather than a period average, to incorporate any potential short-run price changes into our revenue loss calculations. This will provide us with annual revenue loss figures covering the 2002 to 2003 period. We will then also provide a longer term revenue loss forecast whereby we discount the 2002 to 2003 figure under the assumption that the multi-channel elasticity of demand for impacts is -3.0, which was an elasticity figure suggested by Professor Patrick Barwise of the London Business School.

The third point raised was that our model needs to account for the impact that the collapse of ITV digital had on the pay-TV universe, since there was a drop in the pay-TV universe when ITV digital stopped broadcasting at the end of April 2002, with only the free-to-air channels being available to digital terrestrial subscribers. By incorporating the kids' pay-TV universe as a separate variable in our final model and thus using real universe figures as part of our pre-break structural forecasts (indeed, as will be seen below it proves to be highly significant as one of the main explanatory factors), the drop in the pay-TV universe is fully accounted for by our new model.

The fourth point raised was that we needed to account for the possible impact of other competing channels. As we are modelling the impacts of all the main base-tier pay-TV package kids' channels between 01/01/2001 and 13/12/2003, we felt that one of the main variables to consider was competition for the kids' day-parts on the terrestrial channels, and we included this as another variable in the initial model selection process, but it proved not to be statistically significant.

The fifth and final point raised was the potential relevance of more general advertising market indicators. Although these would be much more relevant if we were using revenue rather than impacts as our dependent variable (as impacts are primarily related to audience), we did use total monthly television advertising revenue as a general market indicator as part of our initial model selection process. Here again it proved not to be statistically significant and so was dropped as a variable from the final model.

1.1. Variable Selection

The complex overlapping and drawn out chronology of the principal events affecting the commercial impacts of the main pay-TV children's channels under consideration makes it imperative to develop as robust a model as possible when performing a structural break analysis.[1] The idea is to derive the model of best fit for the entire trend, which will then form the basis for comprehensive structural break testing.

As our dependent variable is the sum total of monthly kids' (4-15) impacts for the BBC's main commercial rivals in pay-TV homes, we must choose explanatory variables for our model selection process that are likely to exhibit a strong and continuous relationship (correlation) with impacts over the three year run (2001-2003) under consideration. The most obvious choice is therefore to use all the main audience measures (Average audience, Share and TVR) for the kids' pay-TV channels under consideration and, for completeness, we are also testing for a significant relationship with total kids' viewing (Total TV) in pay-TV homes. As the commercial impacts of these channels are also likely to be closely related to the pay-TV kids' universe, this must be another variable to consider. Finally, we are testing for significant correlation with the terrestrial competition, in the form of the monthly average audience in pay-TV

[1] There are three main events to consider: the first is the BARB panel measurement error, which was the result of teething problems following a panel re-weighting in January 2002 that took until May 2002 to iron out. The second is the collapse of ITV digital, with the long-running speculation that the venture was on the verge of collapse finally being confirmed by a public admission from Carlton and Granada, on 27 February 2002, that the project was critically flawed and struggling for survival. Final collapse came only two months later, with the switch-off of ITV digital's pay-TV services: on 01 May 2002 owners of ITV digital boxes woke up to a much reduced, effectively free-to-air service (apart from the temporary continuation of the ITV Sports channel, as well as the provision of E4 and Film Four until 24 May). Finally, there is the launch of the BBC's digital children's channels, with the advent of CBBC and CBeebies on 11 February 2002.

homes for kids' day-parts on the terrestrial channels, while any general advertising market influence will be covered by the inclusion of total monthly television advertising revenue as a potential explanatory variable in the model selection process. The full list of variables to be tested is given in Table 1 below.

Table 1: List of Explanatory Variables to be tested in Structural Break Model Selection Process

Dependent Variable (Monthly Average for Kids 4-15 in pay-tv homes: 01/01/2001 to 31/12/2003)	**Impacts** (sum total for Boomerang, Fox Kids, Fox Kids +1, Cartoon Network, Cartoon Network Plus, Nickelodeon, Nickelodeon Replay, Nick JR and Nicktoons)
Independent Variables (Monthly Average for Kids 4-15 in pay-tv homes: 01/01/2001 to 31/12/2003)	**Audience_1** (sum total for Boomerang, Fox Kids, Fox Kids +1, Cartoon Network, Cartoon Network Plus, Nickelodeon, Nickelodeon Replay, Nick JR and Nicktoons)
	Audience_2 (sum total for kids' slots on BBC1, BBC2, ITV, Channel 4 and Five)
	Share (sum total for Boomerang, Fox Kids, Fox Kids +1, Cartoon Network, Cartoon Network Plus, Nickelodeon, Nickelodeon Replay, Nick JR and Nicktoons)
	TVR (sum total for Boomerang, Fox Kids, Fox Kids +1, Cartoon Network, Cartoon Network Plus, Nickelodeon, Nickelodeon Replay, Nick JR and Nicktoons)
	Total TV
	Universe
	TTV_ADS (this is total monthly television advertising spend and is the only variable that covers the entire industry, rather than just Kids in pay-tv homes)

Although one can always argue about including additional variables that might be significant,[2] we feel that the above list is sufficient to derive and impacts model of sufficient robustness for reliable structural break modelling. Indeed, as will be seen below, this is confirmed by the stability and goodness of fit of the final model (when compared to a simple linear trend) derived on the basis of the list in Table 1 above

1.2. Model Selection

In accordance with standard econometric practice, we begin by testing for unit roots in all our time-series variables (including impacts), as this will determine whether we estimate our models using first or even second differences of the variables, or specify them in levels instead. An augmented Dickey-Fuller test rejects the null hypothesis of a unit root in levels at the 5% significance level in each case, and so our estimation can proceed without any differencing of the variables.

[2] An ideal wish list, for example, would have advertising revenue (rather than impacts) as the dependent variable and include, among other things, key advertising industry indicators in the list of initial explanatory variables. Given time and resources, it would also be useful to undertake a detailed analysis of the competitive relationships within the digital kids' television market place, which could eventually be fed back into the structural break model.

As impacts do exhibit a time trend, however,[3] (indeed, this was the basis of our simple structural break model in the report for Nickelodeon outlined in the Introduction above) we will include Time (t) as another potential explanatory variable in our initial model selection process.[4] We also performed a number of test runs of the basic model to see if a log linear specification, as well as the inclusion of lags of the independent variables, might be warranted, but neither proved significant.

Our basic model specification, which will form the basis of our final model selection process, is therefore of the type:

$$Y = \alpha + \beta_0 t + \sum_{i=1}^{i=n} \beta_i X_i$$

Where Y is the dependent variable (i.e. Impacts), α is the regression constant, t is our time variable and β_0 its estimated coefficient, while the X_i's and β_i's represent all the explanatory variables (outlined in Table 1) and their estimated coefficients respectively.

As many of our regressors are highly correlated (ie there is a potential multicollinearity issue), we need to be very careful about what final model selection process we apply, as there is always a danger of ending up with a spurious model specification. We have therefore applied three separate model selection processes independently and compared the final results. The three model selection procedures (within the context of a least squares regression analysis) were:

Backward Selection Procedure:

This is generally one of the most commonly used approaches to model selection, whereby all variables are entered into the equation and then sequentially removed. The variable with the smallest partial correlation with the dependent variable is considered first for removal. If it meets the criterion for elimination,[5] it is removed. After the first variable is removed, the variable remaining in the equation with the smallest partial correlation is considered next. The procedure stops when there are no variables in the equation that satisfy the removal criteria.

Forward Selection Procedure:

A stepwise selection procedure in which variables are sequentially entered into the model. The first variable considered for entry into the equation is the one with the largest positive or negative correlation with the

[3] In technical terms, we are dealing with what is called a trend stationary process.

[4] We use decimal time so that a day represents one unit and our base date is 01/01/1900, making 01/01/2001 equal to 36892.

[5] In accordance with standard econometric practice the removal and/or entry criteria for this, and the subsequent model selection procedures, wis the 5% statistical significance level.

dependent variable. This variable is entered into the equation only if it satisfies the criterion for entry. After the first variable is entered, the next independent variable not yet in the equation that has the largest partial correlation is considered. This procedure stops when there are no variables that meet the entry criterion.

Stepwise Selection Criteria:

At each step, the independent variable not yet in the equation, which has the smallest probability of F (i.e. whose estimated coefficient has the highest level of statistical significance, ie has the lowest probability of being zero), is entered, if that probability is sufficiently small. Variables already in the regression equation are removed if their probability of F becomes sufficiently large. The process ends when no more variables are eligible for inclusion or removal.

In the event, all the procedures gave exactly the same result, a very strong indication that we have managed to establish a robust specification. As a reference guide, some of the statistical outputs of the Backward model selection process have been given in Table 2 below, as these give the best overview of how we arrived at the final specification. Our final model is Model 6, which has been highlighted in Table 2 overleaf.

Table 2: Statistical Outputs of Backward Model Selection Process

Model run for entire series: Jan-2001 to Dec-2003	Independent Variables	Coefficients	Std. Error	t-Statistic	p-value (significant if < 0.05)
Model 1 (Adjusted R Square = 0.743)	(Constant)	-6,950,938	4,726,289	-1.471	0.1529
	Aud_1	38,906	32,571	1.195	0.2427
	Aud_2	-589	652	-0.903	0.3746
	Share	-106,143	136,628	-0.777	0.4440
	TVR	-293,667	1,445,520	-0.203	0.8405
	Total_TV	-3,180	4,312	-0.737	0.4673
	Universe	532	483	1.102	0.2801
	Time	158	108	1.457	0.1566
	TTV_ADS	0.487	0.517	0.942	0.3548
Model 2 (Adjusted R Square = 0.752)	(Constant)	-7,516,453	3,753,617	-2.002	0.0550
	Aud_1	34,961	25,696	1.361	0.1845
	Aud_2	-550	613	-0.897	0.3772
	Share	-114,244	128,424	-0.890	0.3813
	Total_TV	-3,472	3,995	-0.869	0.3922
	Universe	624	175	3.557	0.0014
	Time	164	102	1.602	0.1203
	TTV_ADS	0.465	0.497	0.936	0.3575
Model 3 (Adjusted R Square = 0.754)	(Constant)	-8,550,324	3,545,077	-2.412	0.0224
	Aud_1	12,815	3,299	3.885	0.0005
	Aud_2	-641	602	-1.065	0.2959
	Share	-4,736	24,721	-0.192	0.8494
	Universe	646	173	3.740	0.0008
	Time	141	99	1.435	0.1619
	TTV_ADS	0.646	0.449	1.44	0.1606
Model 4 (Adjusted R Square = 0.762)	(Constant)	-9,028,696	2,475,901	-3.647	0.0010
	Aud_1	12,301	1,890	6.509	0.0000
	Aud_2	-545	330	-1.651	0.1092
	Universe	633	156	4.053	0.0003
	Time	155	69	2.230	0.0333
	TTV_ADS	0.631	0.435	1.452	0.1569
Model 5 (Adjusted R Square = 0.753)	(Constant)	-9,277,174	2,513,744	-3.691	0.0009
	Aud_1	12,626	1,910	6.611	0.0000
	Aud_2	-406	322	-1.263	0.2159
	Universe	648	159	4.087	0.0003
	Time	163	70	2.313	0.0275
Model 6 (Adjusted R Square = 0.749)	(Constant)	-11,317,445	1,944,094	-5.821	0.0000
	Aud_1	12,433	1,921	6.471	0.0000
	Universe	633	160	3.965	0.0004
	Time	217	56	3.869	0.0005

It should be noted that all the coefficients of the final model (i.e. Model 6 in Table 2 above) are highly significant, and additional redundant variable tests confirm this with a very high degree of probability. Finally, we also performed a Durbin-Watson (DW) test for serial correlation, and with a DW statistic of just under 1.6 (given 36 observations and three regressors, excluding the constant) were able to discount this as a potential confounding factor, again supporting the robustness of our final model specification.

On a more intuitive note, the final model specification conforms to logical expectations in that it includes not only a time trend, representing an underlying dynamic growth structure, but also incorporates the channel audiences of the BBC's closest kids' pay-TV rivals, as well as the pay-TV

kids' universe as separate explanatory variables, both of which one would consider to be crucial factors in determining commercial impacts. As already outlined in the introduction above, the presence of these variables in the final model will allow us to account for, and thus effectively remove from our structural break forecast, non-structural step changes like the BARB measurement error and the drop in the pay-TV universe due to the collapse of ITV digital, bringing us much closer to an estimate of the true impact of the BBC's digital children's channels.

1.3. Structural Break Analysis

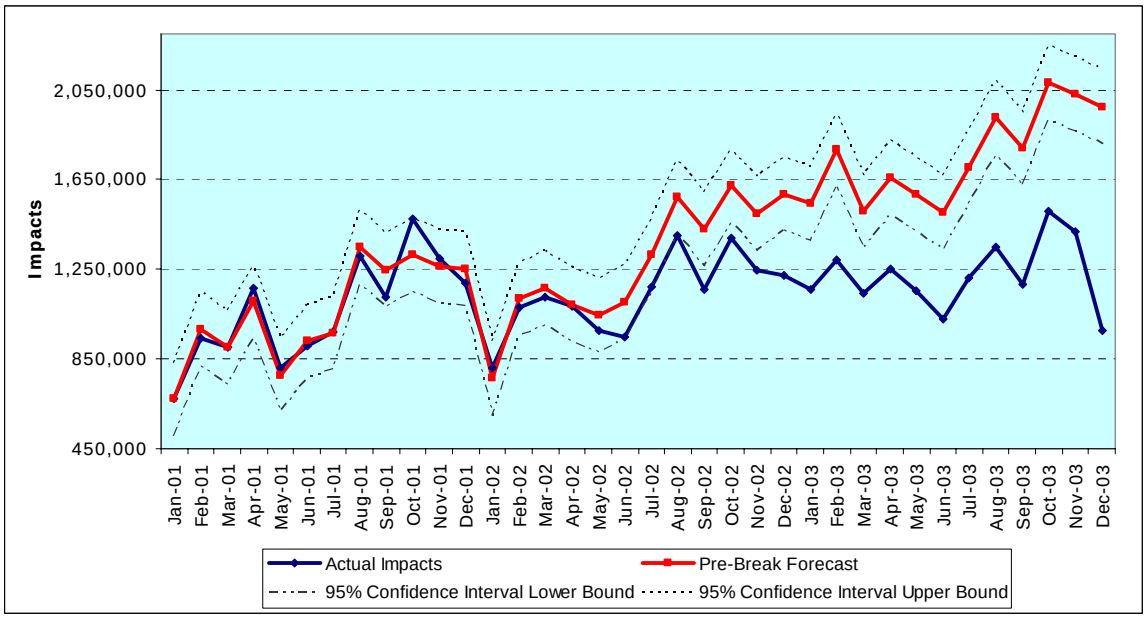
Having established the best explanatory model across the entire three-year trend under consideration, the next step is to test for structural breaks corresponding to significant events. Although a dummy variable approach is adequate when using a simple model of the type employed in the Nickelodeon report, it is much less appropriate when applied to our current model. The complex chronology of events, combined with the model's enhanced sensitivity and more complex structure, makes it very difficult to extract meaningful results using a dummy analysis.

A more sophisticated approach is needed, and we will be using the Chow breakpoint test as the starting point of our structural break analysis. The idea of the Chow break point test is to fit the equation separately for each sub-sample and test for significant differences in the estimated equations.

In view of the complicated chronology of events, as well as the fact that complex structural changes (like the impact of the BBC digital children's channels on the kids' pay-TV market), undoubtedly take time before they are fully realised, it is appropriate to start our search in January 2002, which marks the beginning of a number of potential breakpoint (though not necessarily structural breakpoint) scenarios.

The F-statistic for the Chow breakpoint test (p-value = 0.003121) does indeed prove to be significant for a structural break in January 2002. One must, however, be cautious, as the significance of this date may simply reflect a non-structural step change, like the BARB panel measurement error, with the true structural change, and the associated repercussions on the growth trend in impacts, not occurring until a later point in the time series. Indeed, the best way to resolve the issue of whether we are dealing with a non-structural step change or a true break in the underlying structure of our model, is to use a forecast of impacts over the remaining post-break period (i.e. Jan-2002 to Dec-2003). A significant divergence between our forecast and actual impacts from January 2002 onwards would be strong evidence of a true structural break, while a close correspondence over this period would indicate that we are looking at a step change, and the actual structural change in our model occurred at a later date. The forecast (i.e. post-break projection), under the assumption that a break occurred in January 2002, is given in Figure 1 below.

Figure 1: Forecast of the pre-break trend under the assumption that a break occurred in January 2002



As can be seen in Figure 1 above, there is no statistically significant divergence between our forecast and actual impacts (i.e. actual impacts do not fall outside the 95% confidence interval of our forecast estimates) until around August 2002, from which point onwards we start to observe a statistically significant divergence. Indeed, between the Jan-2001 to July-2002 period our pre-break model predicts actual impacts extremely well, with a goodness of fit measure (i.e. R-Square) of 0.9, indicating that it explains 90% of the variations in actual impacts. This is a very significant finding, as the Jan-2002 to July-2002 period covers two major events that may be interpreted as step (rather than true structural) changes, namely the BARB measurement error (which was rectified by May 2002), and the actual removal of the ITV digital viewers from the pay-TV universe when pay-TV channels stopped being broadcast on the digital terrestrial platform at the end of April 2002. As our model clearly captures these events, this is confirmation that they are in fact step changes and not structural ones. This also makes intuitive sense, since what now remains as the principal factor to explain the actual structural divergence between our pre-break forecast and actual post-break impacts is the advent of CBBC and CBeebies from mid February 2002 onwards which, given that new channels take time to establish an audience, is a factor the structural effects of which would take time to be fully realised.

1.4. Revenue Loss Estimations

In view of the above findings, the best estimate of the loss of commercial impacts to the near pay-TV rivals of CBBC and Cbeebies, due to structural market changes arising from direct competition, would be given by the difference between our pre-break forecast and actual impacts from August 2002 onwards. This gives us an estimated total loss of 7,698,600 impacts over the Aug-2002 to Dec-2003 period, the lower bound of the 95%

confidence interval being 4,889,390 impacts and the upper bound 10,507,809 impacts. This equates to an average annual loss of 5,434,305 impacts, the lower and upper bound of the 95% confidence interval being 3,451,334 and 7,417,276 respectively.

To convert impact losses into revenue ones, we begin by multiplying each estimated monthly impact loss for the Aug-2002 to Dec-2003 period by traded monthly costs per thousand, then summing them to give a total before working out the annual average. This gives an estimated average annual revenue loss of £21.7 million, with the lower and upper bound of the 95% confidence interval being £13.8 million and £29.7 million respectively.

While the above figure covers the short to medium term, a longer term forecast, for which we no longer have actual monthly cost per thousand figures, could take other potential elasticity effects into account. To do this, we could also discount[6] our short to medium term annual revenue loss estimate under the assumption that the elasticity is -3.0 in the multi-channel market, a figure suggested by Professor Patrick Barwise of the London Business School. As an elasticity of -3.0 implies that a 10% fall in impacts results in a 6.7% fall in revenue, we must use a discount factor of 0.67. This results in a predicted annual revenue loss of approximately £14.6 million annually, with the lower and upper bound of the 95% confidence interval being £9.2 million and £19.9 million respectively.

[6] In reality we are double counting elasticity, as the traded monthly CPT figures already reflect elasticity in the short to medium term.