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The Growth of Television Ownership in the United Kingdom

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THE GROWTH OF TELEVISION OWNERSHIP IN THE UNITED KINGDOM

A. D. Bain

1. Introduction and Summary

1.1. The problem of multicollinearity presents itself in an acute form in any attempt to analyse the demand for a new commodity. How are the effects of the economic variables and the "endogenous" growth elements to be disentangled? One approach, which has been adopted by a number of Chicago economists [IV], is to minimize the role of any endogenous element. However, for a commodity like television this would be rather implausible. A second approach involves imposing some given growth path, as in the now classical study of De Wolff [I], or assuming that the endogenous element satisfies certain conditions [VI]. This study belongs to the latter class, but it differs from earlier work in that the economic factors are assumed to determine the endogenous element itself.

The aim of this study of television is the development of a technique for the analysis of the demand for new commodities which may be of general applicability to other new goods.

1.2. Television in the United Kingdom is essentially a post-war phenomenon. The war constituted such a complete break that for practical purposes the first service started in the London area in 1946. The post-war history has four outstanding features: the geographical coverage was extended; a choice of programmes was provided; there were improvements in transmission and reception; and from being drawn initially from the wealthier classes television

owners gradually became more representative of the whole population.[1]

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[1] For further information see [II]

Between June 1946 and August 1952 four major transmitters serving different parts of England and Wales came into operation, and were followed by a number of low power transmitters serving particular localities. In each area a single British Broadcasting Corporation (BBC) programme was provided. Since September 1955 a second programme (ITV), produced commercially, has been extended by stages over the country. Table 1 shows those details of the spread of television transmissions which are important in this analysis.

In many respects the quality of television gradually improved: the duration of weekly transmissions increased, the signal strength became more powerful in some areas, and between 1946 and 1959 the screen of the average television set produced rose from less than 9" to 17". At the end of 1947 nearly half of the television owners were drawn from the top 12% of the population, but by 1953 purchasers of television sets came from the different income groups almost in proportion to their numbers in the population, and since then there has been a tendency for the lower income groups to increase their relative importance. By 1959 the television service available to the mass of the people was quite different from that watched by the select few in 1947.

Table 1: Television Service Dates

BBC Region	Area	BBC Service		ITV Service	
Alexandra Palace[1]					
	London Region	1946	II	1955	III
Sutton Coldfield					
	Midland Region	1949	IV	1956	I
	Leicestershire	1949	IV	1956	I
	Nottinghamshire	1949	IV	1956	I
Holme Moss					
	North West Region	1951	IV	1956	II
	Denbighshire	1951	IV	1956	II
	Lincolnshire	1951	IV	1956	IV
	Yorkshire	1951	IV	1956	IV
Wenvoe					
	Dorset	1952	III	None	
	Somerset	1952	III	1958	I
	Carmarthenshire	1952	III	1958	I
	Glamorgan	1952	III	1958	I
	Monmouthshire	1952	III	1958	I
Low Power					
	North East Region	1953	II	None	
	Cornwall	1954	IV	None	
	Norfolk	1955	I	None	

[1] Later, Crystal Palace

1.3. The model presented is a time-series model explaining the growth of ownership of television in each area. The theoretical assumptions of the model lead to a modified logistic growth curve in which the "saturation" parameter is a function of the programme characteristics of the area, hire purchase deposit requirements, and a cross-section measure of average income levels. This permits the effects of the introduction of ITV and of changes in credit restrictions to be estimated. The "rate of growth" parameter is assumed to be constant except when major adjustments to changes in the saturation level are in progress.

Estimates at quarterly intervals of the proportion of households owning television were calculated for a number of areas in England and Wales from the last quarter of 1952 to the first of 1959. The growth curve was fitted to seasonally corrected first differences of these data in a multiple regression analysis. The time-series parameters were estimated both from the data for each area singly, and from all the areas in each BBC region simultaneously, while the parameter measuring the effect of relative income levels was estimated only from the latter.

The analysis demonstrated that both the introduction of ITV and changes in credit restrictions had considerable effects on the saturation level of ownership. But the precise magnitudes of the estimates need to be regarded with some caution, since there was some evidence that the growth curve postulated gave an adequate explanation of only the central part of the growth curve but was deficient at both extremes.

2. The Model

2.1. Let $f(u,v)\delta t$ be the probability that a household will become television owners in the time interval δt, where u takes account of factors affecting demand in all households and v of variations between individual households. Thus among factors included in u would be the proportion of all households already owning sets, the price of sets, the strength and number of television signals, national income per head and credit restrictions--factors determining the environment in which the household exists; whereas v would include family income, family composition, and education -- the features peculiar to the household. In this analysis the factors included in v are assumed to be constant during the growth process. To make allowance for changes in v would require a cross-section analysis similar to that of Lippett [V], and during the comparatively short period considered large changes in these cross-section variables are unlikely to have occurred. The study is focussed on the effects of some of the factors included in u, which are better suited to time-series analysis.

Suppose that the population of households is divided into n homogeneous groups $\{v_i\}$ $(i=1...n)$. Then $f(u,v_i)\delta t$ is the probability that a particular household in the i'th group will buy a television set in the time interval δt if external conditions are given by u. Within the group $\{v_i\}$ only a certain proportion α_i, called the saturation proportion, will ever acquire a television set, and α_i depends on both u and $\{v_i\}$. If, for example, the price of television is high and $\{v_i\}$

represents a low income group α_i might be very much less than 1, whereas if the price of television were very low α_i might be close to 1. It is assumed, however, that the ultimate saturation proportion α_i, does not depend on the current level of ownership of television (q). Thus α_i $(\leqslant 1)$ depends on $\{v_i\}$ and on some factors in u, but is independent of q.

Let the proportion of $\{v_i\}$ already owning television sets be q_i. Then any new television owners must be drawn from the fraction $(\alpha_i - q_i)$ of the group. A simple hypothesis which reflects the size of the proportion "at risk" is:

$$f(u,v_i)\delta t \propto (\alpha_i - q_i).$$

The influence of social emulation must also be included in the model. It is certainly a simplification to treat the proportion of the whole population owning television as a measure of society's influence on the individual, but as a simple hypothesis in an aggregative model it may well be justified. As an alternative the proportion of some sub-group in the population could be used, but this does not appear to have any clear advantage and is analytically more complicated. Thus $f(u,v_i)\delta t$ is assumed to be directly proportional to q.

$$\text{Hence } f(u,v_i)\delta t \propto q(\alpha_i - q_i)$$

$$= \beta q(\alpha_i - q_i) \text{ where } \beta \text{ is a constant.}$$

Now $f(u,v_i)\delta t$ is the proportion of $\{v_i\}$ expected to purchase a set in

the time interval δt.

$$\text{i.e.,} \quad \delta q_i = f(u,v_i)\delta t = \beta q(\alpha_i - q_i)$$

If the i'th group constitutes a proportion w_i of all households,

$$\delta q = \sum_i w_i \delta q_i = \sum_i w_i \beta q(\alpha_i - q_i)\delta t$$

$$= \beta q(\alpha - q)\delta t$$

where α is the ultimate saturation proportion in the whole population. If the factors in u influencing α are constant this is equivalent to the differential equation of the logistic curve:

$$\frac{dq}{dt} = \beta q(\alpha - q)$$

2.2. The saturation level of ownership is the level which would result from the free choices of consumers in the face of a given price for television if the consumers had stable preferences and their consumption patterns were perfectly adjusted to the prevailing market situation. It is the long-run equilibrium level determined by the conventional theory of rational consumers' behaviour. Even if there were no changes in the characteristics or price of television, or in the financial positions of households, the period after television was introduced in an area would be one of gradual growth to a fixed saturation level while consumers' preferences and consumption patterns slowly adjusted to the new commodity. But the observed growth includes, in addition to this endogenous element, growth which results from changes in the factors which

determine the saturation level.

Historically demand analysts have tended to explain the aggregate consumption of a commodity in terms of incomes and prices. Both are clearly relevant to this analysis. Provided that television is not an inferior good over a wide range of incomes, areas with higher incomes would be expected to have higher saturation levels. Similarly, a reduction in the real price of television sets would tend to raise the saturation level. An income effect has been included in this analysis, although income does not appear as a time series variable. The median incomes of the areas in one particular year order the saturation levels, and the estimated income parameter will include effects from other cross-section economic variables, such as population density, which are correlated with income. Price had to be excluded on practical grounds. There was a high degree of collinearity between levels of ownership (which increased steadily) and prices (which fell steadily in real terms), and it was found impossible to include both in the analysis.

If credit facilities were not available the purchase of a television set would involve the disbursement of a large sum of money in a short period of time. For many people the need to accumulate such a sum would ensure that they did not acquire television. When credit facilities are available, however, this disincentive is greatly reduced, though not completely eliminated. The height of the barrier which remains depends on the size of the deposit required. Hire purchase restrictions in the United Kingdom have stipulated the minimum proportion of the purchase price which may be required as a deposit. The less severe are restrictions the lower is the minimum deposit and the higher is the

probable saturation level. Thus hire purchase deposits have been included as a determinant of the saturation level. This has the indirect effect of bringing price back into the model through the use of a measure based upon the real price of television sets.

The saturation level of ownership is also raised by improvements in the quality of television. These have taken place more or less continuously since the service was first started, with one major discrete change, the introduction of ITV. The effect of continuous gradual improvements cannot be distinguished from the basic growth process, and since improvements are typical of new commodities they may even be regarded as an essential part of that process: but the effect of the major change brought about by ITV can be ascertained. The presence or absence of ITV is therefore included as one of the determinants of the saturation level.

Taken together, these factors suggest the following form for the saturation level:

$$\alpha = \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 h + \frac{\alpha_4}{I}$$

z_1 and z_2 are dummy variables denoting the absence or presence of ITV, h is the hire purchase deposit variable and I is the median income in the area. The use of the reciprocal of I ensures that if α_4 is negative the model will not imply that the saturation level would be greater than unity at some income levels. It is expected that α_2 will exceed α_1, that α_3 and α_4 will both be negative, and that they will together imply that $0 < \alpha \leqslant 1$.

2.3. The parameter β, which measures the speed at which television ownership spread through the population, is related principally to non-economic influences. Such diverse factors as the speed with which information travels and the pressure exerted by neighbours and friends cannot be treated explicitly in this kind of model -- only the end result can be measured.

It was assumed, however, that β took the same value in all sub-groups of the population in any area. When the probable behaviour of different income classes is considered this assumption may seem unrealistic. A durable good requiring a fairly large initial outlay is likely to spread much faster among high than among low income groups. But income groups provide only one classification, and in the absence of an analysis showing precisely how β varied between different groups in the population the simple assumption has been retained.

One source of variation in β which can be taken into account is the time at which a television service started in the area. Knowledge of television was not restricted to the regions in which a service was available. In those areas which received a service comparatively late many people were accustomed to the idea of television before transmissions started. As part of the learning process had already taken place, the rate of growth should be higher in the later than in the earlier regions. Thus β is held constant within regions, but is permitted to vary between regions.

2.4 Some allowance must be made for a seasonal pattern in growth. The purchase of a set results partly from a desire for possession and partly from a desire for consumption. Fashion and novelty influence the former, whilst more permanent factors like the mean temperature or length of daylight in the evenings are related to the latter. As ownership becomes more general consumption influences are likely to increase in relative importance. Thus the seasonal pattern in new ownership will change during the growth process.

Let $\beta_s = \beta - \omega_s$ be the rate of growth parameter applicable to the s'th quarter, where ω_s is a constant $(s=1...4)$ and $\sum_s \omega_s = 0$. Then the observations of ownership at the end of the s'th quarter lie on a logistic curve, and the harmonic mean of the curves for the four quarters is also a logistic with rate of growth β. This mean can be regarded as the trend growth curve. At any stage of the growth process the ratio of the actual to the trend change in ownership in the s'th quarter is constant and equal to $\frac{\beta - \omega_s}{\beta}$.

If $\omega_s = \eta_{1s} + \eta_{2s}\, q$ where η_{1s} and η_{2s} are constants $(s=1...4)$ and $\sum_s \eta_{1s} = \sum_s \eta_{2s} = 0$, the quarterly observations no longer lie on exact logistic curves, but the trend curve remains the logistic with rate of growth β. The ratio of the change in the s'th quarter to the trend change depends on the level of ownership and is given by $\frac{\beta - \eta_{1s} - \eta_{2s} q}{\beta}$ $(s=1...4)$. Thus during growth this ratio moves from an initial value of $\frac{\beta - \eta_{1s}}{\beta}$ to a final value of $\frac{\beta - \eta_{1s} - \eta_{2s}\alpha}{\beta}$, which conforms to the seasonal pattern postulated above.

2.5. The final model can now be formulated in detail. The equation of the basic growth path is:

$$\frac{dq}{dt} = \beta q\ (\alpha - q)$$

The saturation level is defined as:

$$\alpha = \alpha_1\ z_1 + \alpha_2\ z_2 + \alpha_3\ h + \frac{\alpha_4}{I}$$

where z_1 and z_2 are dummy variables denoting the absence or presence of ITV, h is the hire purchase and I the income variable.

For the s'th quarter in the i'th BBC region the rate of growth parameter is defined as:

$$\beta_{is} = \beta_i - \eta_{1s} - \eta_{2s}\ q$$

$$= \beta_i\ (\mu_{1s} + \mu_{2s}\ q)$$

where $\mu_{1s} = 1 - \frac{\eta_{1s}}{\beta_i}$ and $\mu_{2s} = \frac{\eta_{2s}}{\beta_i}$

Hence $\frac{dq}{dt} = \beta_i\ q\ (\mu_{1s} + \mu_{2s} q)\ (\alpha_1\ z_1 + \alpha_2\ z_2 + \alpha_3\ h + \frac{\alpha_4}{I} - q)$

is the final form of the growth equation.

3. The Data

3.1. The data to be analysed consist of the proportion of households possessing a television set in a number of areas of England and Wales, expressed as a time series at quarterly intervals from 1952 IV to 1959 I. Television licence statistics [III] show the number of licences in each County, and these are divided by an estimate of the number of households to give the proportion owning television. The estimates of households take account of the growth of population, of movements between Counties and of changes in the average size of household. Although they are not very exact they are unlikely to lead to any substantial errors in the analysis.

The licence statistics give rise to more significant problems. First, the correspondence between the licences allocated to a County and the County boundary is imperfect. In four conurbations the problem of allocating licences to the appropriate area had to be met by considering a number of Counties as a single region.[1] Secondly, a television licence does not necessarily imply a

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[1] London region consists of the Counties of London, Essex, Kent, Middlesex and Surrey; Midland region of Staffordshire, Warwickshire and Worcestershire; North East region of Durham and Northumberland; and North West region of Cheshire and Lancashire.

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television owning household. Some households rent their sets, but since rental agreements have been subject to controls similar to the hire purchase controls there is no reason to treat rented sets separately. Thirdly, some licences are held by institutions and some households evade the licence fee.

Therefore a margin exists between the total of licences in an area and the total of television owning households. Estimates of this margin in different areas have been made from time to time on the basis of sample surveys.[1]

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[1] These have been carried out by the BBC Audience Research Department and by Television Audience Measurement Limited.

Until 1955 the margin was generally about 10%, but more recently estimates range from 6% to 10 1/2% according to the area. No attempt has been made to correct the data for this margin, but it must be borne in mind in interpreting the results of the analysis.

To be included in the analysis an area had to satisfy three requirements: it had to fall in a single BBC region; if it had any ITV service it had to fall in a single ITV region; and the area had to be sufficiently large fo licence data to give a reasonably accurate estimate of the change in ownership in any quarter. These requirements were satisfied by 16 areas.

3.2. The hire purchase series is computed by multiplying a retail price index, which measures movements in the real price of television sets, by the minimum legal proportionate deposit. The appropriate charge for purchase tax and a retail margin of 30% were added to the index of wholesale prices of television receivers[2] to give the retail price of television receivers

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[2] The index of wholesale prices of television receivers, published in the Board of Trade Journal (H.M.S.O., London), is a constant quality index.

in money terms. This was converted to real terms by dividing by the Interim Index, or Index of Retail Prices. Thus the hire purchase series measures movements in the minimum proportion of the real price of television which must be paid before acquiring a set.

3.3. Details of the distribution of personal incomes before tax in each of the Counties of England and Wales can be obtained from Inland Revenue surveys [VII]. The median income found in the 1954-55 survey was calculated for each area. The income data used were the deviations from their mean of the reciprocals of these median County incomes.

4. Estimation Procedure

4.1. For the purpose of parameter estimation the differential equation showing the rate of growth at each point on the curve was converted to a difference equation showing the amount of growth in a short (unit) time-interval. Thus

$$q_{t+1} - q_t = \Delta q_t = \beta_i q_t(\mu'_{is} + \mu_{2s} q_t)\ (\alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_4 z_4 - q_t)$$

$$S=1 \ldots 4$$

where $z_3 = h$

and $z_4 = \frac{1}{I}$

is the change in ownership in a unit time period. This can be

rewritten as

$$\Delta' q_t = \frac{\Delta q_t}{\mu_{1s} + \mu_{2s} q_t} = \beta_i q_t \sum_{j=1}^{4} \alpha_j z_j - \beta_i q_t^2$$

where $\Delta' q_t$ is the "seasonally corrected" value of Δq_t .

The estimation was performed in two stages. First, the parameters μ_{1s} and μ_{2s} $(s=1...4)$ were estimated and values of $\Delta' q_t$ computed. Secondly, these computed values were used as the dependent variable in the estimation of the economic parameters.

4.2. The ratio of the actual to the trend rate of growth in the s'th quarter is equal to $\mu_{1s} + \mu_{2s} q^*_{t+1/2}$, where q^*_t is the trend level of ownership at time t. In first differences this can be stated as

$$\frac{\Delta q_t}{\Delta q^*_t} = \mu_{1s} + \mu_{2s} q^*_{t+1/2}$$

The trend values, q^*_t, were estimated as the four quarter moving average, centred on time t, of the observed values of q_t .[1]

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[1] When the variable $\frac{\Delta q_t}{\Delta q^*_t}$ is formed the use of a moving average is unlikely to cause any serious problem of serial correlation.

Then the parameters μ_{1s} and μ_{2s} were estimated by ordinary least

squares from the equation

$$\frac{\Delta q_t}{\Delta q_t^*} = \mu_{1s} + \mu_{2s} q^*_{t+1/2} + \epsilon_t$$

where ϵ_t is a homoscedastic random error term, and $\sum_{s=1}^{4} \mu_{1s} = \sum_{s=1}^{4} \mu_{2s} = 0$.

Finally, the seasonally corrected first differences,

$\Delta' q_t = \frac{\Delta q_t}{m_{1s} + m_{2s} q^*_t}$ (s=1...4), were obtained from the estimates

m_{1s} and m_{2s} of μ_{1s} and μ_{2s} respectively.

It should be noticed that in this formulation the seasonal pattern is a property of the area under analysis. When the data for a single County are being analysed the seasonal pattern applies only to that County; but when estimates are made together for all the areas in a BBC region the seasonal pattern is assumed to be the same in all the component areas. This is analogous to the postulate that the growth parameter is the same in all areas within a BBC region.

4.3. Before continuing with the regression analysis some further adjustments were made to the $\Delta' q_t$ to remove the disturbing effects of anticipated changes in the programme characteristics and of the Coronation in 1953. The introduction of a new television service was always announced in advance, with the result that some people had decided to acquire a set

before the service was provided. In the case of the BBC service purchases reflecting these decisions were spread over the first few quarters, giving a rate of growth higher than that which was consistent with later observations. In the case of ITV there was apparently a slight tendency to delay purchases until the service was actually available, with a higher rate of purchase subsequently. But the observed early deficiency in growth may not correspond to any real deficiency because the precise date of purchase is obscured in licence data by the time lag between the purchase of a set and the purchase of a licence. The televising of the Coronation stimulated a considerable increase in sales, which is reflected in the licence statistics for the second and third quarters of 1953.

An attempt to estimate the size of these effects was made in a preliminary analysis by comparing residuals from curves fitted to the data of many of the areas. It was impossible to obtain precise estimates of the necessary adjustments, but the following appeared adequate to remove the bulk of the effects. In the first four quarters of a BBC service $\Delta' q_t$ was multiplied by 0.6, 0.7, 0.8 and 0.9 respectively; in the first three quarters of an ITV service by 1.1, 0.9 and 0.9 respectively; and in the second and third quarters of 1953 by 0.7 and 0.9 respectively.[1]

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[1] Since the adjustments were derived from the data used in the subsequent analysis there is some reduction in the degrees of freedom remaining. But this is not large, since 9 parameters were estimated from the data of 16 areas. On average the loss is less than 1 degree of freedom per area and has been ignored in the regression analysis.

4.4. Let the $\Delta' q_t$, adjusted where necessary, be written as y_t. Then the estimating equation has the form

$$y_t = \sum_{j=1}^{4} \gamma_j q^*_{t+1/2} z_j - \beta_i q^{*2}_{t+1/2} + \epsilon_t$$

where $\gamma_j = \beta_i \alpha_j$

and ϵ_t is a random error term discussed below.

$q^*_{t+1/2}$ is the trend value of ownership at the mid-point of the time-interval determining the dependent variable.[1] The parameters

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[1] It can be shown that the difference approximates the differential equation more closely if the trend value used corresponds to the mid-point, rather than either end, of the time-interval.

γ_j ($j = 1...4$) and β_i have been estimated by ordinary least squares from this equation. Then the ratios $\frac{\gamma_j}{\beta_i}$ give estimates of the α_j.[2]

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[2] If the variances of the estimates of γ_j and β_i are respectively $\sigma^2_{\gamma_j}$ and $\sigma^2_{\beta_i}$, the variance of the estimate of α_j can be obtained from the approximate formula

$$\sigma^2_{\alpha_j} = \frac{1}{\beta_i^2} \sigma^2_{\gamma_j} + \frac{\gamma_j^2}{\beta_i^4} \sigma^2_{\beta_i} - \frac{2\gamma_j}{\beta_i^4} \operatorname{cov}(\beta_i \gamma_j)$$

Least squares estimation will give best linear unbiased estimates provided that the expected value of ϵ_t is zero, that the variance of ϵ_t is constant, and that the ϵ_t are uncorrelated with the independent variables for all t. The dependent variable was adjusted in order to remove the forseeable violations of the first condition.[1] When it is

[1] It must be remembered, however, that the estimated values of the α_j will differ from the true values by a margin resulting from licence evasion.

considered that the ϵ_t arise from both the errors in the data and from incomplete specification of the factors determining growth there is no reason to expect any large differences in the error variance over the range of the curve. But the covariance between ϵ_t and the independent variables is not zero because part of ϵ_t can be attributed to the difference between the observed and the true values of q_t^*. However, in this case, the resulting bias will be very small.[2] Thus least squares estimation appears appropriate

[2] It can be shown that if the errors in the independent variables are $\underline{E}$ and in the dependent variable $\underline{\epsilon}$ the bias in the parameter estimates is proportional to $\mathcal{E}(\underline{E}'\underline{\epsilon})$. In this analysis ϵ is derived from the differences between successive observations on q, while the $\underline{E}$ are derived from the sums of successive observations. On the assumption that the errors in successive observations are independent and normally distributed with zero mean $\mathcal{E}(\underline{E}'\underline{\epsilon}) = 0$ and the parameter estimates are unbiased. Even if the assumption is not exactly correct the bias is likely to be very small.

for this analysis.

5. Results

5.1. Estimates were obtained using the data from each area separately ("single") and pooling the data from all the areas in a BBC region together ("group"). More accurate estimates of the influence of the independent variables were obtained by averaging the estimates of the same parameter obtained from different areas.[1] These averages may be preferable to

[1] Minimum variance averages were calculated using weights inversely proportional to the variances of the parameter estimates.

estimates derived directly from the pooled data in that only the parameter in question is held constant for all the areas in the group. The parameter estimate is then less heavily dependent on the assumptions of the model. But in general there is little difference between the values obtained by averaging the single area estimates and the group estimate. Viewed from another angle this can be regarded as support for the assumption that the effect of the independent variables is the same in the different areas.

The three areas served by low power transmitters have been treated as one group, although they did not receive a service simultaneously. To simplify the computation of the group estimates some observations were omitted, ensuring that the data for all the areas began in the same quarter of the year. Thus, in this case, the single and group estimates are not derived from identical data.

5.2. The seasonal parameter estimates are shown in full in Appendix tables A and B, while the estimates from the grouped data are given in table 2. The estimated variances of the seasonal trends are much larger than those of the seasonal constants, and within BBC regions the former show much more variation. Nevertheless, a glance at tables A and B demonstrates that a consistent pattern has emerged.

Table 2: Seasonal Parameter Estimates

REGION	Seasonal Constants				Seasonal Trends			
	m_{11}	m_{12}	m_{13}	m_{14}	m_{21}	m_{22}	m_{23}	m_{24}
Alexandra Palace	1.13	1.09	0.62	1.16	-.13	-.99	.25	.87
Sutton Coldfield	0.90	0.85	0.99	1.26	.11	-.41	-.48	.78
Holme Moss	0.93	0.82	0.84	1.41	.40	-.45	-.28	.32
Wenvoe	0.92	0.71	0.83	1.54	.72	-.20	-.44	-.09
Low Power	1.03	0.59	0.80	1.58	.13	-.09	-.30	.26

The bulk of television purchases are made in the first and fourth quarters of the year, the proportion tending to increase as ownership rises. When a service was first introduced between 55% and 65% of new sets were licensed in these quarters, but by the time half the households in an area owned television this proportion rose to nearly 70%. The fourth quarter

itself accounted for 40% of the new licences taken out each year. The second and third quarters were less important and both declined. Initially the third quarter accounted for a larger share of annual purchases than the second, but at 50% ownership they each supplied 15% of the total. The tendency has been for purchases in the winter months to predominate and to increase in relative importance.

The seasonal trends seem to be less strong in the later than in the earlier regions.[1] This confirms the view that novelty affects the seasonal

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[1] The estimates for Alexandra Palace are rather unreliable, being based on only one region.

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pattern. Purchases were initially more evenly distributed over the year in the earlier regions. In the later regions, where novelty had apparently less influence, seasonal variation was quite pronounced from the outset.

5.3. The parameter estimates obtained in the analysis, together with their standard errors, are contained in Appendix tables C, D, and E. The estimates of the parameters determining the saturation levels in the individual areas, contained in table C, can be interpreted in the following way:

a_1 = the saturation level before ITV when no hire purchase deposit is required.

a_2 = the saturation level after ITV when no hire purchase deposit is required.

a_3 = the effect of hire purchase restrictions.

The ratios of their standard errors to the estimates of a_1 and a_2 range from just over 5% to under 20%, while the errors of the a_3 are of the same order as the estimates themselves. The values of R^2, the proportion of the sum of squares explained, range from 0.94 to 0.98.

Table D shows the estimates obtained in the group analysis by BBC regions. Within each BBC region the income series does not have mean zero because a series common to all the areas was used. The parameter estimates can therefore be interpreted as follows:

a_1 = the saturation level before ITV at the mean income of the areas included when no hire purchase deposit is required.

a_2 = the saturation level after ITV at the mean income of the areas included when no hire purchase deposit is required.

a_3 = the effect of hire purchase restrictions.

a_4 = the effect of the variation in income levels.

The standard errors of a_1 and a_2 range from under 6% to 12% of the estimates, while the errors in a_3 and a_4 range from under 20% to the same order of magnitude as the estimates. The values of R^2 are still of the order of 0.95.

The estimates of β for single areas and for BBC regions are

shown in table E.[1] The standard errors of the regional estimates lie

[1] The regional estimate for the Alexandra Palace transmitter is not strictly comparable with the others because it is the estimate for the London Region only and no income parameter could be included in the estimating equation.

between 9% and 18% of the estimates, compared with a range of from 10% to 30% for the single areas.

It is worth noting at this stage that the estimates of β for the Sutton Coldfield and Holme Moss regions lie well below the single estimates of their component areas. Conversely, the estimates of a_1 and a_2 are considerably higher in the group estimates.

5.4. The estimates of the saturation levels before and after ITV, obtained by both single and group procedures, are shown in table 3. They are calculated as if there were no credit restrictions, and the group estimates incorporate the effect of the income parameter. To obtain the ultimate saturation expected in an area an allowance for evasion must be added to these estimates. It seems that about 7% for the Wenvoe region, 8% for the Sutton Coldfield, Holme Moss and Low Power groups, and 10% for the London Region would be appropriate.

Table 3 (See Page 26)

In comparing the estimates obtained by the single and group procedures one feature has already been noticed. Allowing for evasion the group estimates for Sutton Coldfield and Holme Moss are implausibly

Table 3: Saturation Levels - Pre-ITV and Post ITV

Area	Single		Group	
	Pre-ITV	Post ITV	Pre-ITV	Post ITV
London Region	0.58	0.62	-	-
Midland Region	0.74	0.75	0.83	0.78
Leicestershire	0.74	0.76	0.87	0.81
Northamptonshsire	0.82	0.86	0.89	0.84
North West Region	0.70	0.71	0.85	0.84
Denbighshire	0.68	0.64	0.77	0.76
Lincolnshire	0.71	0.81	0.82	0.81
Yorkshire	0.70	0.77	0.86	0.85
Dorset	0.62	-	0.59	-
Somerset	0.51	0.59	0.62	0.71
Carmarthenshire	0.79	0.85	0.65	0.74
Glamorgan	0.67	0.77	0.68	0.77
Monmouthshire	0.65	0.75	0.71	0.79
North East Region	0.81	-	0.68	-
Cornwall	0.67	-	0.75	-
Norfolk	0.84	-	0.74	-

Table 4: The Mean Values of Saturation Levels

Region	a_1	standard error	a_2	standard error
Alexandra Palace	0.58	0.047	0.61	0.035
Sutton Coldfield	0.75	0.054	0.77	0.040
Holme Moss	0.70	0.032	0.75	0.025
Wenvoe	0.60	0.031	0.68	0.032
Low Power	0.78	0.046	-	-

high. But while the single estimates indicate a rise in the saturation level after the introduction of ITV the group show a fall. The implications of this fall, in contradiction of theory, will be discussed later.

In the Wenvoe region the general level of the single and group estimates is the same, though in the latter case the saturation levels rise in ascending order with income. Of the Low Power estimates the level of those obtained by the group procedure seems much more reasonable than that of the single, although the higher saturation levels have been ascribed to areas with lower incomes. This can be explained by the heterogeneous nature of the group.

Table 4 (See Page 26)

The means of the single area estimates provide fairly accurate assessments of the pre-ITV and post-ITV saturation levels in each of the BBC region. They are shown in table 4. The aggregations performed in obtaining these estimates are legitimate, because in no case do the individual parameter estimates differ significantly from their regional mean.[1] However,

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[1] The tests of significance in this study were all two-tailed tests using student's "t" distribution. The significance level is 5% unless otherwise stated.

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significant differences between regions preclude any further aggregation. By the addition to a_2 of a margin for evasion it can be seen that the ultimate saturation levels range from about 70% to 85% in the different parts of the country.

Table 5 (see below)

The overall effect of ITV on the saturation level can be estimated. In this case it is legitimate to calculate both the regional means and an overall mean, the results being given in table 5. It will be observed that the estimates derived from single areas are more accurate than those derived from groups. This, together with the unsatisfactory signs of two of the group estimates, suggests that the single estimates give a better measure of the effect of ITV. It can be said with some confidence that ITV was responsible for an average rise of over 7% in the saturation level.

Table 5: The Effect of ITV

Region	Single		Group	
	$a_2 - a_1$	standard error	$a_2 - a_1$	standard error
Alexandra Palace	0.037	0.032	-	-
Sutton Coldfield	0.026	0.038	-0.051	0.066
Holme Moss	0.073	0.017	-0.010	0.032
Wenvoe	0.089	0.012	0.088	0.013
All Regions	0.077	0.009	0.070	0.012

5.5. Table 6 shows the estimates of the parameters measuring the effect of hire purchase on the saturation level. The single estimates given are the minimum variance means for each region of the estimates for the individual areas, while the 'All regions' estimates bear the same relation to the estimates for their components. The regional means computed from single

area estimates have smaller standard errors than their group counterparts. None of the regional estimates differs significantly from the overall mean.

Table 6: The Effect of Hire Purchase

Region	Single		Group	
Alexandra Palace	0.35	2.49	-	-
Sutton Coldfield	0.35	3.52	3.64	5.12
Holme Moss	-4.05	1.74	-5.17	2.87
Wenvoe	-4.79	1.74	-4.90	2.31
Low Power	-9.85	3.26	-5.08	6.21
All Regions	-3.78	1.00	-4.13	1.64

To be theoretically satisfactory the parameter estimate must have a negative sign, implying that more severe credit restrictions are associated with lower saturation levels. By this test the estimates for the Alexandra Palace and Sutton Coldfield regions are unsatisfactory, but all these estimates are much smaller absolutely than their standard errors, and the positive sign is not at all certain. The single estimate for the Low Power group seems rather high, the group estimate being at a more reasonable level. The other estimates accord well with expectations, and the overall means of the single and group estimates are remarkably close.

The values of the hire purchase deposit series range from 138 to 0. Thus the maximum overall effect of credit restrictions has been a lowering of the saturation level by just over 5% on average. The abolition of hire

purchase restrictions at the end of 1958 would raise saturation levels by just under 5%. At first sight this does not seem a great increase, yet the effect on new purchases would be quite marked. If the actual level of ownership were, say, 15% below the saturation level a rise of 5% would increase first purchases.

5.6.

Table 7: The Effect of Income

Region	$a_4 \times 10^3$	$\sigma_{a_4} \times 10^3$
Sutton Coldfield	3.58	2.14
Holme Moss	-6.21	1.51
Wenvoe	-3.53	0.60
Low Power	1.55	0.76

Table 7 contains the estimates of the income parameter obtained in the group analyses. The standard errors are quite large in relation to the estimates, and two estimates have a positive sign. If the saturation level is expected to be higher in the areas with higher incomes the parameter must have a negative sign since the income series is based upon the reciprocal of the incomes in each area. In both the Holme Moss and Wenvoe regions there is a considerable variation in income and the signs of the estimates are negative, but the variation is much less in the Sutton Coldfield region where the sign is reversed. If the dependence of the saturation level on income is not very close this might give rise to a positive estimate. But the

Low Power group cannot be explained in this way: that there is a considerable variation in income is shown clearly by the size of the standard error. In this case the sign must be attributed to the effect of constraining the β parameter to have the same effect in all the areas. If the hypothesis that the rate of growth is higher in those areas which received a television service later is correct this would lower the estimated saturation level in the North East Region and raise it in the other areas, thus tending to reverse the sign of the income parameter.

The estimates for the Holme Moss and Wenvoe regions both provide for variations of about 10% in the saturation levels of their component areas. In the Holme Moss region the estimate for Yorkshire is 9% above that for Denbighshire, while in the Wenvoe region Monmouthshire is 11% above Dorset. The estimates of the income parameter in the four regions differ so greatly and for such special reasons that it does not appear possible to make any overall estimate of the effect of income.

5.7. The estimates of the growth parameter β for the BBC regions are shown in table 8. Except in the Low Power group there is little to choose between the standard errors of the single and group estimates, and the values of b are higher in the newer television areas. No great reliance can be placed on either of the Low Power estimates. The high standard error of the group estimate reflects the fact that the single estimate is the mean of individual area estimates which themselves differ significantly. Thus the evidence supports the theory that the rate of growth was higher in the later BBC regions.

Table 8: The Growth Parameter

Region	Single		Group	
	b	σ_b	b	σ_b
Sutton Coldfield	0.137	0.020	0.107	0.019
Holme Moss	0.202	0.016	0.150	0.017
Wenvoe	0.266	0.019	0.240	0.021
Low Power	0.216	0.018	0.277	0.042

6. Evaluation

6.1. A number of substantive conclusions were reached in this study. The saturation levels of television ownership and the effects of ITV and of credit restrictions on these levels were measured. It was shown that, "ceteris paribus", television ownership spread faster in areas which received a service later. The success of this analysis in separating the effects of different variables suggests that the techniques used may be helpful in the study of the demand for other new commodities.

6.2. But some features of the growth of television ownership did not fall neatly into the framework of this model. It will be recalled that in some areas the estimated saturation levels seemed unduly high, and ITV apparently induced a slight fall. Both these features would be explained by a decline in the parameter β over the range of the curve. For if in fact β declined a constant estimate would underestimate β initially and overestimate it later. When a discontinuity in the saturation level is postulated the estimated saturation level reacts by taking a high value initially and a lower

value later. Thus the theoretical rise in the saturation level would be reduced or transformed into an observed fall. Only in the Wenvoe region was there no evidence of this decline, and in that region ITV was in operation for only a short period. Perhaps the most important conclusion of this study for future research is that the simple logistic growth path is not wholly satisfactory, and that some positively skewed distribution would be preferable.

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APPENDIX:

Table A: Seasonal Constants

BBC Region	Area	m_{11}	m_{12}	m_{13}	m_{14}
Alexandra Palace		1.13	1.09	0.62	1.16
	London Region	1.13	1.09	0.62	1.16
Sutton Coldfield		0.90	0.85	0.99	1.26
	Midland Region	0.91	0.69	1.00	1.40
	Leicestershire	1.05	0.86	1.01	1.08
	Northamptonshire	0.81	0.99	0.90	1.30
Holme Moss		0.93	0.82	0.84	1.41
	North West Region	1.00	0.94	0.83	1.23
	Denbighshire	0.77	0.85	0.86	1.53
	Lincolnshire	0.87	0.81	0.81	1.50
	Yorkshire	0.90	0.72	0.96	1.42
Wenvoe		0.92	0.71	0.83	1.54
	Dorset	0.87	0.83	0.77	1.52
	Somerset	1.00	0.76	0.90	1.35
	Carmarthenshire	0.94	0.72	0.80	1.55
	Glamorgan	0.76	0.85	0.85	1.54
	Monmouthshire	0.95	0.64	0.87	1.53
Low Power		1.03	0.59	0.80	1.58
	North East Region	0.96	0.63	0.97	1.44
	Cornwall	1.03	0.69	0.69	1.59
	Norfolk	1.04	0.45	0.87	1.64

Table B: Seasonal Trends

BBC Region	Area	m_{21}	m_{22}	m_{23}	m_{24}
Alexandra Palace		-0.13	-0.99	0.25	0.87
	London Region	-0.13	-0.99	0.25	0.87
Sutton Coldfield		0.11	-0.41	-0.48	0.78
	Midland Region	-0.24	0.28	-0.29	0.25
	Leicestershire	0.06	-0.60	-0.70	1.24
	Northamptonshire	0.37	-0.93	-0.26	0.81
Holme Moss		0.40	-0.45	-0.28	0.32
	North West Region	0.09	-0.62	-0.19	0.72
	Denbighshire	1.35	-0.61	-0.59	-0.15
	Lincolnshire	0.38	-0.41	-0.19	0.21
	Yorkshire	0.50	-0.29	-0.50	0.30
Wenvoe		0.72	-0.20	-0.44	-0.09
	Dorset	0.71	-1.38	0.04	0.63
	Somerset	0.04	-0.15	-0.47	0.59
	Carmarthenshire	1.71	-0.41	-0.57	-0.73
	Glamorgan	0.94	-0.45	-0.33	-0.16
	Monmouthshire	0.64	0.02	-0.71	0.05
Low Power		0.13	-0.09	-0.30	0.26
	North East Region	0.40	0.03	-0.71	0.28
	Cornwall	0.23	-0.65	0.13	0.29
	Norfolk	-0.11	0.22	-0.60	0.49

Table C: Estimates of Parameters for Single Areas

Area	a_1	σ_{a_1}	a_2	σ_{a_1}	a_3	σ_{a_3}
London Region	0.58	0.047	0.62	0.035	0.35	2.49
Midland Region	0.74	0.093	0.75	0.063	-1.34	5.37
Leicestershire	0.74	0.074	0.76	0.058	6.81	6.04
Northamptonshire	0.82	0.154	0.86	0.112	-6.14	7.38
North West Region	0.70	0.063	0.71	0.046	-3.19	3.80
Denbighshire	0.68	0.107	0.64	0.067	-1.99	5.24
Lincolnshire	0.71	0.054	0.81	0.047	-6.39	2.93
Yorkshire	0.70	0.058	0.77	0.047	-2.76	3.06
Dorset	0.62	0.060			-1.29	3.58
Somerset	0.51	0.050	0.59	0.045	0.40	2.83
Camarthenshire	0.79	0.133	0.85	0.114	-11.37	6.17
Glamorgan	0.67	0.075	0.77	0.068	-3.11	4.28
Mormouthshire	0.65	0.079	0.75	0.072	-3.38	4.59
North East Region	0.81	0.064			-8.65	3.88
Cornwall	0.67	0.087			-9.75	8.47
Norfolk	0.84	0.096			-15.32	8.20

Table D: Estimates of Parameters for BBC Regions

BBC Region	a_1	a_2	$a_3 \times 10^4$	$a_4 \times 10^3$
Sutton Coldfield	0.92 (0.11)	0.87 (0.07)	3.64 (5.12)	3.58 (2.14)
Holme Moss	0.81 (0.06)	0.80 (0.05)	-5.17 (2.87)	-6.21 (1.51)
Wenvoe	0.65 (0.04)	0.73 (0.04)	-4.90 (2.31)	-3.53 (0.60)
Low Power	0.70 (0.08)	-	-5.08 (6.21)	1.55 (0.76)

Note: Standard errors are shown in brackets below the estimates.

Table E: Estimates of β for Single Areas and BBC Regions

BBC Region	Area	b	Standard Error
Alexandra Palace		0.170	0.027
	London Region	0.170	0.027
Sutton Coldfield		0.107	0.019
	Midland Region	0.145	0.040
	Leicestershire	0.135	0.028
	Northamptonshire	0.133	0.041
Holme Moss		0.150	0.017
	North West Region	0.197	0.034
	Denbighshire	0.181	0.046
	Lincolnshire	0.208	0.027
	Yorkshire	0.207	0.028
Wenvoe		0.241	0.021
	Dorset	0.287	0.034
	Somerset	0.314	0.046
	Carmarthenshire	0.209	0.044
	Glamorgan	0.251	0.041
	Monmouthshire	0.262	0.048
Low Power		0.277	0.042
	North East Region	0.195	0.019
	Cornwall	0.510	0.092
	Norfolk	0.270	0.050