Forecasting Ski Demand: Comparing Learning Curve and Varying Parameter Coefficient Approaches

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ABSTRACT
Demand for skiing expanded rapidly in the 1980s, fell quite dramatically at the start of the 1990s as the economy declined but has not subsequently recovered. Two possible explanations are explored. The first is based on perceiving skiing as a new product to most consumers, which reached maximum growth in 1989. Current levels now largely represent 'repeat buyers'. The alternative approach sees the growth as the result of economic factors, particularly credit conditions. The importance of these factors was not, however, constant, and grew with the changes in the financial system. Thus the recovery had a muted effect. These two approaches are modelled, estimated and the results compared by both residual and ex post forecasting analysis. The paper concludes that the varying coefficient econometric model probably produces the most reliable forecasts. Copyright © 1999 John Wiley & Sons, Ltd.

KEY WORDS forecasting; skiing; tourism; time series; learning curve; econometric; varying coefficient

INTRODUCTION
Throughout the 1970s and 1980s the UK underwent fundamental economic and cultural change. Some groups, particularly professionals in private practice and wealth owners, experienced substantial increases in income while others, often young, experienced low wages, unemployment and often accumulated substantial debt.

At a cultural level foreign travel, boosted by the free advertising of ‘Holiday’ television programmes, became a normal activity. In addition, increasing leisure time and a growing interest in outdoor sport led to the rise of the ‘Activity’ holiday. Together these economic and cultural changes led to the dramatic rise in the skiing holiday as illustrated in Figure 1.

The 1990s saw a collapse in this market almost as spectacular as the previous rise. As with house prices, most commentators at the time associated the decline with the collapse in discretionary income brought about by high interest rates and the substantial rise in price associated
with the weakening of the pound against the European currencies. Recovery in the economy, however, has not been reflected in a return in either housing or skiing markets; forecasts based on simple economic explanations were simply incorrect. This paper attempts to utilize two radically different approaches to gain a better understanding of what has actually happened, and thus to generate forecasts that might have some accuracy.

PREVIOUS WORK

Accurate demand forecasting is central to profitable tourist operations and consequently there have been numerous attempts at developing accurate and effective model based forecasting methods. Witt and Witt (1995) record 40 different published papers on forecasting tourist demand, covering about 150 country-to-country flows. The vast majority of these studies are causal (econometric) in form, normally relating demand to income, price/cost and, for quarterly data, season. Skiing as a separate market with specific features does not feature in any of these studies.

Witt and Witt (1991) report on the comparative performance of time series and econometric models for forecasting tourist demand. Learning curve models, based on the Gompertz, were used in the study but the simple form failed to impress in comparison to the econometric methods.

As the review articles by Meade (1984) and Meade and Islam (1995) make clear, learning curve models are most usually associated with new products, and the growth of these products through a market to saturation. The study by Bain (1963) of the demand for new products (colour televisions) is an early example. With the exception of the Witt and Witt (1989) paper there are no examples of application in the tourist area, and no examples of a model incorporating an existing and new market such as proposed in this paper.

THE DATA

This paper is concerned with the mass skiing market; the thousands who travel on chartered flights from the UK to Europe. For this paper, the ski market is defined as the numbers of people
on charter flights from UK airports to the airports close to the major European ski resorts: Geneva, Salzburg, Lyon, Lucerne, Toulouse, Milan, Munich, Verona and Chambery. Data was collected from the monthly CAA publication *Airport Statistics* for the skiing months December to April for 1973 to 1996.

Inevitably this series may be criticized for excluding the North American market and the overland services by bus, car and rail and including those travelling on winter holidays but not skiing. There is little evidence, however, of any shifts to these alternative locations or modes of a size sufficient to seriously affect the contention that the series is a good measure of skiing demand in the UK.

**THE LEARNING CURVE MODEL**

The basic characteristics of the learning curve is an S-shaped model of product penetration, a slow start followed by rapid growth, which tails off as saturation is approached. The period-by-period change in penetration results in a hump-backed model of new demand. Later, replacement demand shadows new demand at a period defined by the product life. However, because product life varies, the resulting demand wave is damped and converges to that fraction of the total market that should be replaced on the basis of average life. Riddington (1984) found a damped wave pattern of this form for demand for Combine Harvesters in the UK.

While in 1973 a skiing holiday was not a ‘new’ product, in earlier years it had been confined to a relatively small group of the affluent. The growth of charter holidays in the summer led to a supply of cheap charter flights in winter and consequently opened up skiing to a completely new market. Of these new skiers an unknown fraction were so attracted to the activity that they have returned and now form a relatively stable committed market.

Putting these elements together we obtain a learning curve model of the form:

1. A constant \( a \) that represents the stable market of the 1960s; subsector 1
2. The logistic learning curve \( Y_t = \frac{1}{1 + \frac{S}{a} \cdot \exp^{-\gamma t}} \) where \( Y \) is the total who have purchased the product, \( S \) is the saturation level and \( \gamma, \beta \) are unknown parameters
3. New skiers \( N_t = Y_t - Y_{t-1} \); subsector 2
4. Retained skiers \( R_t = \delta \cdot Y_t \); subsector 3

Total demand is thus made up of the stable market, new skiers and retained skiers and is determined by the time, the unknown saturation level \( S \) and the four unknown parameters \( a, \beta, \gamma, \delta \).

**ESTIMATION OF THE LCM**

Inevitably economic factors will affect all three subsectors and a perfect fit could not be expected. In this model these stochastic effects are expected to be proportionate to the demand and small. Thus the values of the parameters were chosen in order to minimize the mean absolute percentage difference between the value predicted by the model and the actual value. Alternative estimates were also obtained by minimizing the sum of the normalized error squares but showed little difference and appear no less defensible than the criteria chosen.

The estimating procedure was relatively straightforward using Excel. Initial values were obtained by visual comparison of the graph of the initial data and the graph of the data generated...
by the model. When an approximate fit was obtained, the ‘Solver’ was used, with Gauss–Newton iteration, to find the minimum MAPE. The graph of the actual versus estimates is given in Figure 2.

The estimated model is

Saturation \( S \) 962,000; retention rate \( \delta \) 0.098; subsector 1 \( (z) \) 42,200

Learning curve parameters; \( \beta 0.587 \gamma 4.445 \)

For comparison purposes a pseudo-\( R^2 \) was calculated as 99.3%.

ECONOMETRIC APPROACHES

Despite the logic and fit of the LCM some might argue that it was unlikely that a turning point in a learning cycle would exactly match the turning point in an economic cycle and that whatever the reasons for the growth the collapse undoubtedly had an economic base. An income-based explanation has, however, two major problems. First, like house prices, skiing demand appears to be an I(2) series, whereas all the supposed explanatory factors such as real discretionary income or exchange rates are I(1). In modern terminology they cannot be co-integrated and hence cannot have a long-term causal relationship.

A second critical factor is that real income does not fall until 1992 whereas ski demand starts to fall in 1991. Real income clearly does not Granger-cause ski demand. It should be noted here that, throughout the paper, real as opposed to monetary values were used, under the assumption that there was no money illusion.

In a search for a better explanation than simple income, the impact of substantially increased housing costs (resulting from house price inflation and very high interest rates) on the under-30s was investigated. Although in itself the effect was difficult to ascertain, the effect of debt itself came to the fore. One series that could be I(2) (although it could also be I(0)) was consumer credit which exhibited the same explosive growth and contraction as ski demand. However, instead of debt reducing discretionary income and hence ski demand, ski demand seemed to correlate with the ease of obtaining credit (monetary looseness) in the economy. As a result the best single explanatory variable was found to be real M4, the measure of broad money supply in real terms.

For most economists M4 tends to be viewed as the result of economic activity rather than the cause. However, in this case it is a useful aggregate, combining income and credit conditions and
largely reflecting the economic climate for the individual making a decision on something like a foreign holiday. If the government attempts to control M4, it operates through interest rates and indirectly through bank lending. Interest rates affect mortgage payers, typically skiers, disproportionately, while government action to restrict bank lending tends to affect the young who again are over-represented among skiers. The hypothesis that M4 does have an effect on ski demand is thus not unreasonable.

In addition to the general economic climate as a determining factor, the ‘trend’ towards second and activity-based holidays cannot be ignored if an adequate explanation of skiing demand is to be provided. As a rough proxy, therefore, of the economic and cultural climate a time trend and M4 are used and we obtain a simple initial model

\[ Q_t = \alpha + \beta M4_t + \gamma T + \epsilon_t \]  

where \( Q_t \) is the number of skiers per annum in thousands
M4 is broad money in 1982 prices in £bn
T is the time period 1973 = 0
\( \epsilon \) is a stochastic term

This was estimated as:

\[
Q_t = -59.8 + 0.23 * M4_t + 8.3 * T + \epsilon_t \quad R^2 = 0.93 \quad DW = 1.24 \SE in brackets
\]

Given some concern about first-order autocorrelation, on most grounds this would appear to be a satisfactory model with most other key statistics indicating no serious problems. However, Ramsey’s reset test of functional form and the Watson–Davis test of the stability of individual parameters both hint at a deeper problem. While M4 broadly mimics the pattern of ski demand, it does not provide a full explanation. M4, like the time trend, is an I(1) series. A clear possible solution first appeared when examining the recursive regression of demand against M4. The trace of the parameter coefficient, given in Figure 3, clearly shows that demand has become more and more sensitive to monetary conditions over time.
This result is both unsurprising and revealing about why the economy has failed to recover as rapidly as anticipated. Despite a strikingly obvious change in the recursive estimates, the traditional measures of parameter constancy; Cusum, Cusumsq and Chow, failed to identify any structural shifts. However, as Song (1992) points out, these measures are only really applicable if the change is discrete, if there is clearly a single point of change. When change is continuous the Watson–Davis test is currently the best measure and this suggested change on the parameter of M4.

A relatively easy confirmation that there has been parameter change is to assume that the change is linear and can be modelled by

\[ \beta_t = a + bT \]  

Substituting equation (2) in (1) gives a model of the form

\[ Q_t = \alpha + aM4_t + bT*M4_t + \gamma T + e_t \]

The LM test for excluded variables indicated that a new variable T*M4, added significant new information to the equation. However, when estimated the statistical explanation only marginally improved, both constant and M4 became insignificant and the problem of serial correlation increased. An alternative varying coefficient model was required.

THE VARYING COEFFICIENT MODEL

Although Riddington (1993) has shown that the varying coefficient model has an excellent forecasting record, the general specification is still comparatively rare. The approach taken here is to specify the model in state space form and then use the EM algorithm, which is based on the Kalman filter, to obtain good approximations of the parameters before final refinement using Gauss–Newton. In this case the final model has the form

\[ Q_t = \alpha + \beta_{t-1}M4_t + \gamma T + e_t \]
\[ \beta_t = \beta_{t-1} + \delta + \omega_t \]

where \( \delta \) is a constant and \( \omega_t \) is zero mean normally distributed system noise.

The estimated coefficients were:

<table>
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<tr>
<th>Value</th>
<th>standard error</th>
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<tr>
<td>31</td>
<td>18</td>
</tr>
<tr>
<td>4.44</td>
<td>1.18</td>
</tr>
<tr>
<td>0.0048</td>
<td>0.0082</td>
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</table>

The \( \hat{R}^2 = 0.962 \), DW = 1.3.

Figure 4 traces the parameter \( \beta_t \) over time. In simple terms the trace suggests that until the changes in the financial system in 1981, the public were not affected by monetary aggregates such as M4. The massive increase in lending institutions and the substantial rise in indebtedness
has led to credit conditions becoming a determinant in major purchasing decisions such as holidays.

Figure 5 shows that the fit of the VCM is better than that of the FCM, particularly in the early years. In essence, because the effect of monetary conditions has grown in recent years, applying the current parameter to early years greatly overstates the importance of the variable. This is
more clearly seen in Figure 6, which compares the errors generated by the three models. What is also noticeable is that no other clear error patterns emerge.

FORECAST PERFORMANCE

In order to gain insight into the forecasting performance of the three models they were re-estimated omitting the last four years of data and an *ex-post* assessment of forecast performance carried out. The results are given in Table I.

As might have been expected, without the last four years of poor results in the data set, both the fixed coefficient and learning curve models consistently over-estimate market demand. However, although the coefficient trace (Figure 4) suggested that the responsiveness to credit conditions mitigated after the problems at the start of the decade, the under-estimation of demand in 1991, 1992 and 1993 by the VC model was still surprising. On the basis of the MAPE and the general error pattern the VC model would appear to be ‘better’ than both learning curve and fixed coefficient alternatives.

Table I. *Ex-post* forecasting errors from the three models

<table>
<thead>
<tr>
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<th>VCM</th>
<th>FCM</th>
<th>LCM</th>
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<tbody>
<tr>
<td></td>
<td>Error</td>
<td>APE</td>
<td>Error</td>
</tr>
<tr>
<td>1991</td>
<td>-11.36</td>
<td>6.95</td>
<td>4.14</td>
</tr>
<tr>
<td>1992</td>
<td>-17.10</td>
<td>11.14</td>
<td>2.73</td>
</tr>
<tr>
<td>1994</td>
<td>12.22</td>
<td>8.26</td>
<td>33.53</td>
</tr>
<tr>
<td>Mean</td>
<td>-6.37</td>
<td>8.00</td>
<td>12.73</td>
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CONCLUSIONS

This paper has set out to compare a univariate ‘learning curve’ approach to understanding and forecasting demand for skiing, with fixed and variable coefficient multivariate models. Both general approaches provided insight, and indeed are probably complementary.

To many people in 1973 a skiing holiday in the Alps was clearly a new product. This is similar in many ways to the situation for summer tourism. Every few years, tour operators establish new destinations for the mass market; examples in the 1990s from the UK would be Florida, Cyprus and Turkey. Each of these destinations will have the same growth, decline and stable (retained) pattern exhibited by skiing. However, the speed and success of the introduction is critically dependent upon the economic environment at the time, just as the collapse of the skiing market had its roots in the problems of the UK economy.

Medium- and long-range forecasting is not a mechanical exercise but a process of assembling and weighting information from a wide variety of sources. The models developed in this paper clearly help this process, but the eventual weighting between the varying approaches in the end still lies with the forecaster.

A NOTE ON COMPUTATION

Recursive regression and Chow, Cusum and Cusumsq tests were carried out using Microfit.

Variable coefficient estimation and the Watson–Davies test were carried out using Forecast Master.

The estimation of the learning curve model and all other computational work was carried out using Excel for Windows V 7.0.

APPENDIX: SKI DEMAND 1973–94

<table>
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<tr>
<th>Year</th>
<th>Total</th>
<th>Year</th>
<th>Total</th>
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<td>1981</td>
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<tr>
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</tr>
<tr>
<td>1983</td>
<td>109.86</td>
<td>1994</td>
<td>147.98</td>
</tr>
</tbody>
</table>

REFERENCES


Author’s biography:
GEOFF RIDDINGTON is Senior Lecturer in Quantitative Economics at Glasgow Caledonian University. He obtained a PhD in Methods of Forecasting Demand in the Medium and Long Term in 1973 and has maintained a strong interest ever since. He is particularly interested in varying coefficient approaches and the role of subjective priors in improving econometric modelling and forecasting.

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