Modelling Product Life Cycles from Customer Choice

Sonia Skelton, Thomas Lynch, Craig F. Donaldson and Michael H. Lyons.
Advanced Applications and Technologies
British Telecommunications Laboratories
Admin 2
Martlesham heath
Ipswich
Suffolk
United Kingdom
IP5 7RE.

Tel: +44 1473 646300
Fax: +44 1473 646921

Abstract

Increasing competition in markets, rapid advances in technology and changing organisational styles have contributed to a reduction in product life times and development cycles. The telecommuncations industry is becoming very complex with a vast array of products and services, many of which are at least partially substitutable for one another. It is becoming increasingly important to have tools which help companies manage their service portfolios. This paper presents an investigation into product life cycles from the perspective of customer choice. A simulation model, based on a system dynamics approach, was developed and the impact on market growth of various influences analysed. Results suggest the model may be used to investigate product life cycles and to evaluate and compare commercial strategies.

This modelling activity provides a valuable insight into the potential predictability of product life cycles, the amount a telecommunications service provider may influence a product life cycle and the applicability of system dynamical analyses to an organisation's commercial strategy.

Introduction

The telecommunications industry is currently in the process of great change in every aspect of its business. Rapid economic, regulatory, technological, social and political changes have all had considerable influence on the way in which telecommunications organisations operate. To succeed in this fluctuating environment, products and services must be innovative and quick to market. Telecommunications services have traditionally required heavy investment in development. Increasing competition has led to a reduction in product lifetimes (Quails, 1981) in many industries. For example, during the last ten years companies such as Intel, IBM and Philips have reduced their product development cycles by over fifty percent (Kotler, 1994). As the number of potential telecommunications services increase, similar pressures will reduce the development cycle of new services. New products and services must address customer needs and enter the market quickly to recoup investment.

Managing an organisation's portfolio will require a deep understanding of the factors determining a product's life cycle. In this paper, we develop an approach to modelling product life-cycles based on the way customers choose whether or not to buy a new service. In this paper, the term "customer" and "user" refer to the end user who may purchase a service.

The model is applied to historic data for the UK fax market. It is shown that the model can reproduce many different types of market growth and can be used to analyse the impact of different marketing and product strategies. It is concluded that a service provider may be able to exert some influence on the product life cycle of a new service

Product Life Cycle Classes

The product life-cycle is defined here as the level of sales (measured in units sold) over a product's lifetime (Kotler, 1994). Experience has shown that dividing a product life cycle into distinctive stages (such as introduction, growth, maturity, decline and senility) enables useful generalisations to be made of its main characteristics, the strategy alternatives available and the most appropriate

marketing mix for the implementation of each strategy option (Catry, 1974; Onkvisit, 1986; Howard 1981). In the past, product life cycles were estimated from historical data; the stage a product was going through and the length of that stage being estimated from a mixture of extrapolation and experience.

In general, sales of a new product will show three main stages: (i) slow growth when the product is first introduced, (ii) a period of rapid growth as it becomes established in the market, and (iii) a period of slow or zero growth as the market reaches saturation. In some cases this may be followed by a fourth stage: decline, as the product is displaced by newer offerings. Although the general trend is well known, the growth of a market with time can show many variations depending on the relative durations of the three main periods. A number of market diffusion equations have been developed to represent these different growth curves. Work by Manchester Business School (Easingwood, 1988) has resulted in a model, the Non-Uniform Influence Model (NUI), which reproduces the many observed life-cycle curves.

In the Non-Uniform Influence Model (NUI) market growth is described by the equation:

$$S(t) = a[\tilde{N}-N(t)]+b\left[N(t)/\tilde{N}\right]^n \left[\tilde{N} -N(t)\right]$$

where:

$\tilde{N}$ = saturation level,
$S(t)$ = number (or density) of new adoptions at time t,
$N(t)$ = cumulative adoptions at time t,
a = constant called the coefficient of internal influence,
b = constant called the coefficient of external influence,
n = non-uniform influence factor.

The model is an extension of the Bass Model (Bass, 1969) but can generate a richer variety of product life cycle curves. Like the Bass model it divides the potential customer base into innovators and imitators. Innovators buy a product with a certain probability regardless of its market share (a coefficient term), while imitators are affected by the current market share of the product under consideration (b coefficient term). The nature of the imitative effect of the Bass model can be seen to represent the growth in uptake of a service as the total number of customers grows. This is appropriate for networked services for which growth in total number of customers increases the value of the service to new customers. For example, videophone services offer greater service potential if more customers have videophones.

Combining any arbitrary value of n with any value of b generates an infinite number of different curves, which may be divided into nine distinct classes. Each class corresponds to a particular range of values of the diffusion model parameters, b and n, such that all diffusions in a particular class have a distinctively shaped diffusion curve (Figure 1). For each class Manchester Business School gave possible reasons underlying the shape of the life cycle characterisitic. For example, class 7 could represent a product which is of poor quality but is expected late in its life cycle to undergo a substantial upgrade in quality. An awareness of the stage and overall shape of a life cycle would enable an organisation to optimise its future commercial strategy.

Manchester Business School concluded that the NUI model was sufficiently flexible to accommodate a wide variety of diffusion patterns, depending on the value of *b* and *n*. However, the significance in market terms of the non-uniform influence factor *n* is not clear and this limits the value of the model when applied to new telecommunications services.

The work of Kotler and Baker (Baker, 1986) is consistent with that of the Manchester Business School. They propose that the success or failure of a new product and the product life cycle it generates, depend on a number of factors, together with a prospective customer's behavioural response to those factors. Factors relate both to the market and the product or service itself. These factors may include performance, reliability, utility, marketing support, price and distribution. The mix of these factors will strongly influence the product life cycle. By concentrating on the behavioural response of potential users to these factors, it is envisaged that a

product life cycle may be simulated prior to the launch of the actual product, thus providing valuable information for resource allocation decisions and future commercial manoeuvring.

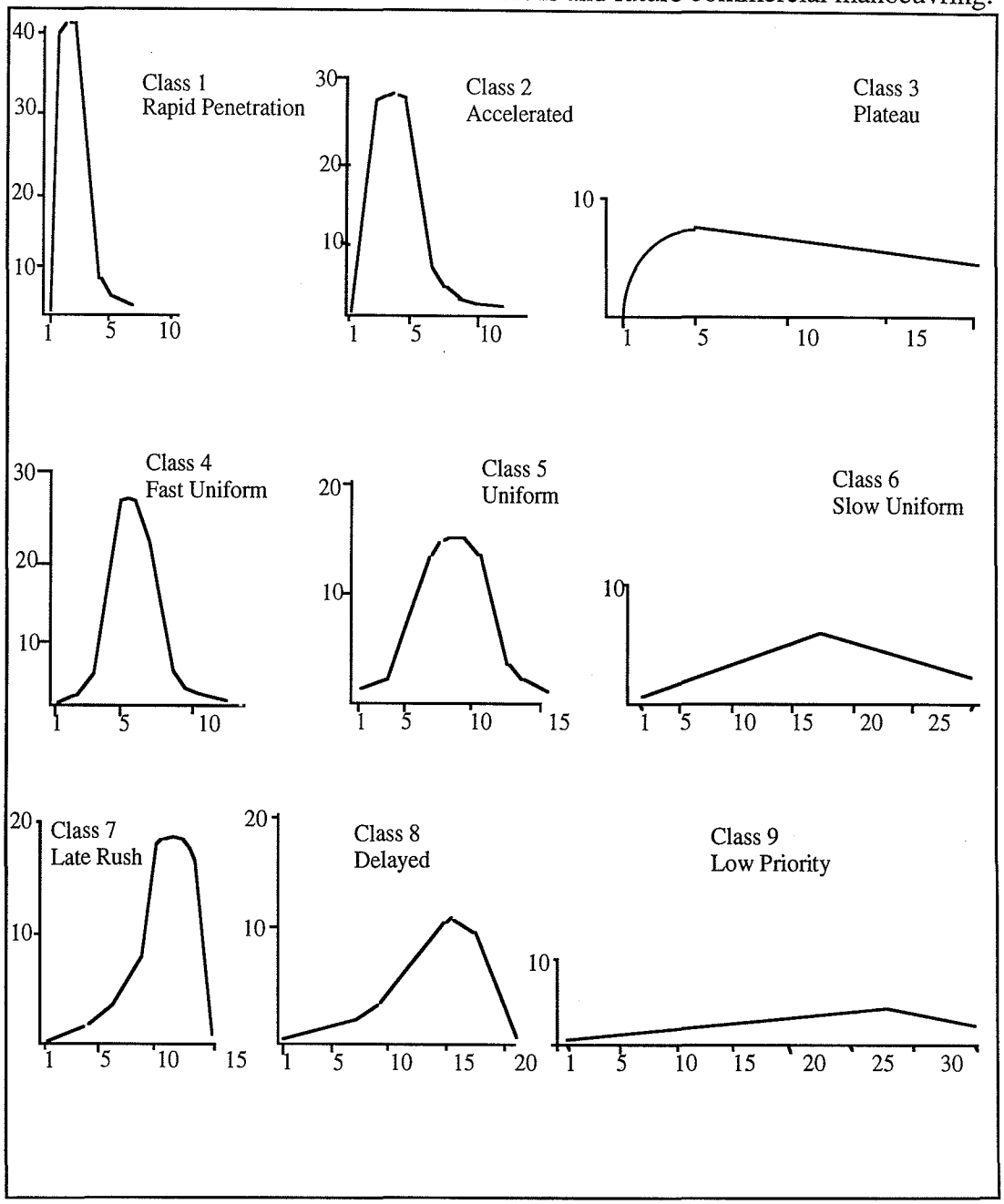


Figure 1: New product diffusion classes distinguished by % market penetration vs. time (years) profiles

System Dynamics approach to product life cycle modelling

There are a large number of factors that influence a potential customer's decision to purchase a product. These factors could include the quality of a product or service and consumer awareness of the product. The influence that these factors will have on the purchase decision and on the other factors will vary with time. Thus, product sales are inherently dynamic. Given these considerations, a system dynamics approach was adopted to build a model which generates product life cycles from the influence certain factors have on a prospective customer's purchasing

decision. For example, advertising expenditure and customers' perceived need for a service can both influence new service diffusion. (Forrester, 1965).

System dynamics models encompass the uncertainty and complexity of a problem and allow sensitivity analysis to be carried out in order to identify how the influence of factors varies over time. The technique allows the gaming of scenarios and has already been used to study telecommunications problems such as demand modelling(Barnes, 1994), competitive positioning (Lyneis, 1994) and global telecommunications service provision (Lynch, 1994).

Overview Of Customer Choice Model

The decision making procedure a customer goes through when deciding to purchase a new service was broken down into a number of stages (Figure 3).

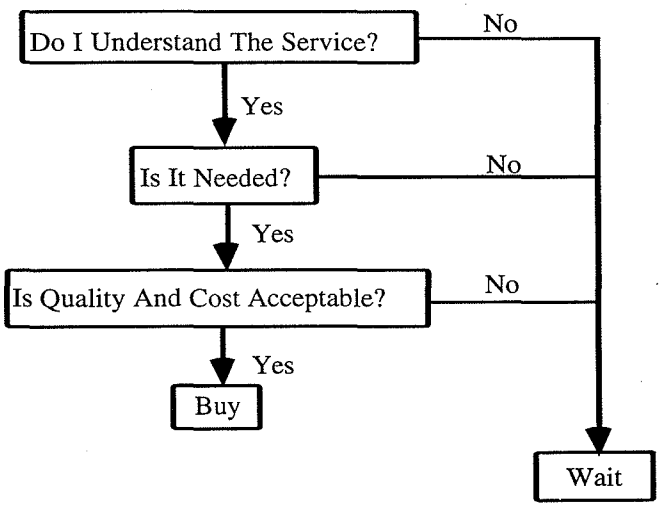


Figure 3: Model flow diagram

The major factors determining a customer's decision to buy are: understanding of the service, its utility and its acceptability. The service provider will have an influence over each of these factors depending on its commercial strategy, as shown schematically in Figure 4.

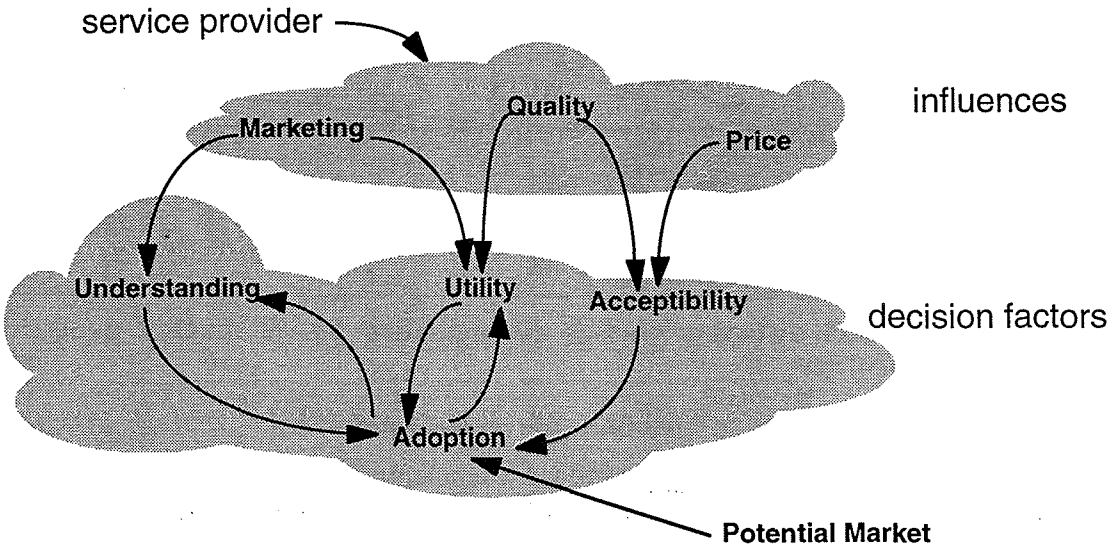


Figure 4: Overview of the customer choice model

The model itself incorporates a number of decision making sectors which run simultaneously: understanding; utility; acceptability; and adoption.

Decisions will be dependent on the values of the influencing factors: marketing, quality and price. Understanding is influenced by a service provider changing the amount of marketing and word of mouth from new adopters in the adoption sector. Utility, or the value of the service to the customer, is influenced by quality and marketing which are controlled by a service provider and by changes of cumulative adoption in the adoption sector. The acceptability of a service is influenced by price and quality which are assumed to be controlled by a service provider. It is beyond the scope of this paper to consider the impact of system externalities, such as changes in price and quality of input products to the service provider.

Output from each decision making sector is a fraction which represents the probability a customer understands the service, has a need for the service or finds the service acceptable. These fractions are passed into the adoption sector where the overall probability of purchase is calculated. The probability of purchase is then applied to the potential market and annual adoption calculated.

Results

In order to provide a basis for the modelling exercise, the historical launch of Group 3 fax machines in the UK was considered (Dataquest 1993). Initial results are based on this data and more general application postulated.

The saturated market figure for the fax base in *business* has been estimated to be currently 1.5 million machines. This figure does not include the sale of fax for home usage.

Verification of the Model - UK Facsimile Market

Adoption of fax in the UK began in the late seventies and followed a slow but steady growth until the late eighties when there was a significant increase. This is believed to have been due to the one off event of the 1987 UK postal strike, although there are suggestions that new consumer services often take-off when the price falls below a critical threshold.

Figure 5 illustrates the actual and calculated adoption of fax from 1980. When considering the two plots in Figure 5, it can be seen that the diffusion figures derived from the model, which include the effect of the postal strike, compare extremely well to the actual historical data. By 1994 approximately 59% of the potential market had actually adopted fax compared to the calculated figure of 60%.

To produce the effect of the UK postal strike, the actual utility and price acceptability were significantly increased for the duration of the event, demonstrating that the model can be used to explore the knock-on effects of events occurring in the past.

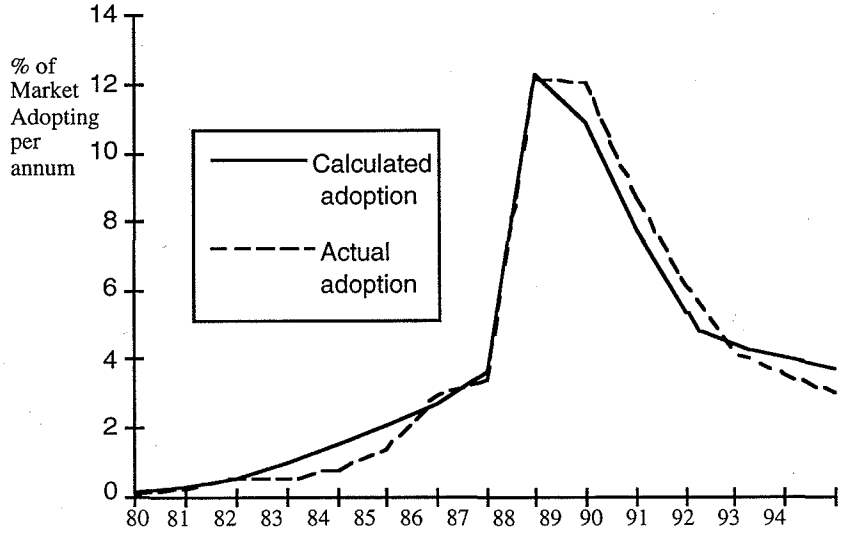


Figure 5: Graph of adoption of fax machines versus time

Diffusion of Fax With & Without the Postal Strike

Removing the effects of the postal strike allowed comparison of how the fax market would have diffused without this event. The consequent revenue from both unit sales and usage charges could also be investigated.

Figure 6 gives some indication of the impact that the postal strike had on the diffusion of fax. The peak of the product life cycle for the actual adoption of fax was 12% per annum of the total market in 1988. With the removal of the postal strike, the peak take up of the new product life cycle was 6% per annum of the market in 1994. Revenues from unit sales would have been consequently affected.

From the classification of product life cycles in Figure 1 the life cycle of fax machines changed from slow uniform (class 6) to fast uniform (class 7). Manchester Business school ascribed such general behaviour to a significant increase in quality, but in this case change occurred due to a significant increase in the perceived utility of fax due to an uncontrollable event - the UK postal strike.

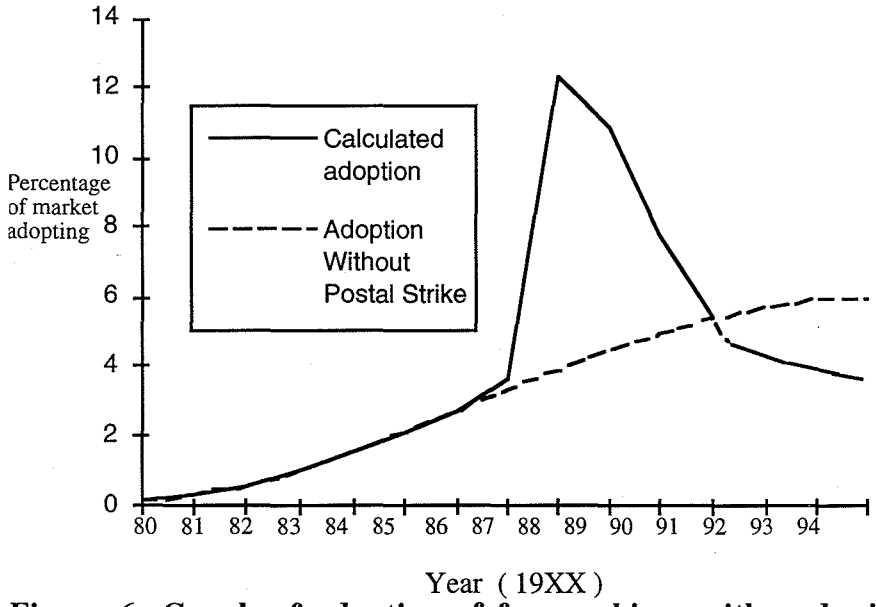


Figure 6: Graph of adoption of fax machines with and without the postal strike versus time

Other areas which highlight the impact of the postal strike on the diffusion and profitability of fax are the market share and usage revenue. By 1992 fax had been adopted by approximately 52% of its potential market. According to the model without the postal strike, fax would only have been adopted by approximately 32% of its potential market.

The model could have been used prior to 1986 to estimate future take up of fax, but clearly it could not account for major external events such as the postal strike.

Analysis of Fax Diffusion

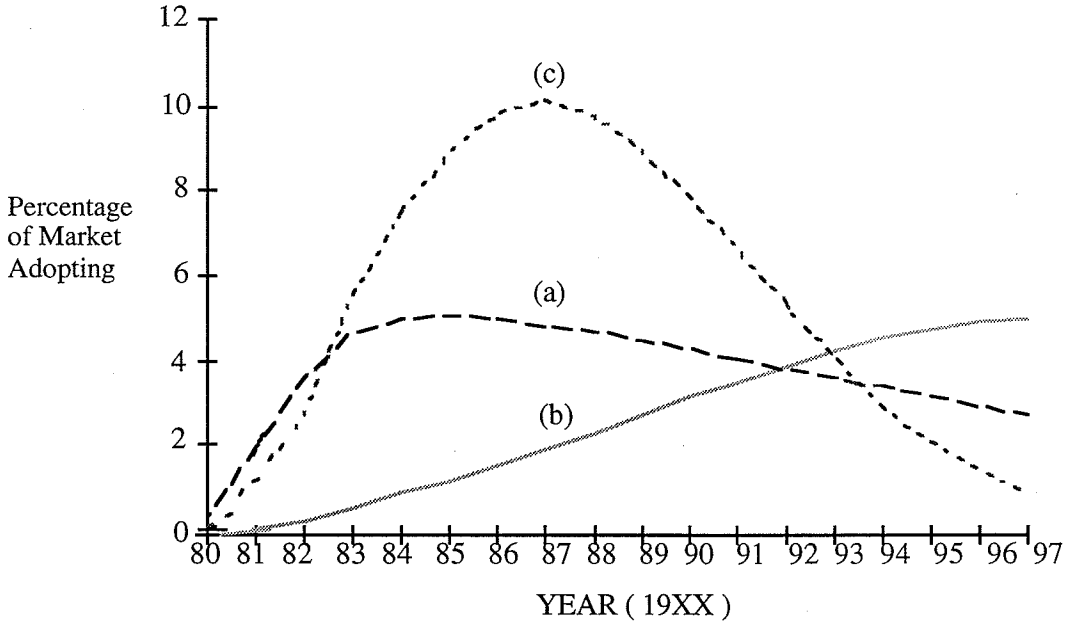
The model was then used to investigate alternative strategies. It was seen that the model could produce a range of different outcomes depending on the values of the decision criteria. By applying a number of commercial strategies to maximise fax adoption, life cycles which fitted several life cycle classes were generated. In Figure 7, it can be seen that 3 of these classes have been produced with the application of strategies concerning investment in quality and marketing over time. Therefore, even though the service is the same, the predicted product life cycle is moved through a number of different classes according to the strategic decisions taken.

From Figure 7 it can be seen that investing in quality or marketing, although changing the product life cycle, does not produce maximum cumulative adoption for the case of fax. When investing the entire annual budget into marketing (a) the service produces a class 3 plateau life cycle (Figure 1). This plateau shape is the result of the market becoming aware of the service

very early and a number of innovators adopting the service very quickly. After approximately 5 years, adoption levels off and remains at an approximately constant level. New purchases are made as utility increases - a result of the steady increase in the fax base.

Investing the entire annual budget into improving the quality of service produced a life cycle described as low priority (b), class 9 (Figure 1). The market is unaware of the service and therefore unaware of any increase in quality. Gradually diffusion accelerates as satisfied customers, through word of mouth, make more people aware of the service.

Adoption is greatly improved by the annual budget being invested on the factor that has the greatest influence in both present and future time periods (c). To achieve this a number of scenarios must be applied and an understanding gained of the influence each variable has and when this influence will have its maximum effect.



(a) Budget Spent On Marketing

(b) Budget Spent On Quality

(c) Budget Divided Between Quality And Marketing To Achieve Maximum Cumulative Adoption by 1992

Figure 7: Graph of adoption versus time showing effect of varying marketing and quality spend

The product life cycle generated by applying a strategy to maximise adoption of fax was in class 5 (Figure 1). This was produced by the market initially being made aware of the service by the entire annual budget being spent on marketing. Subsequently, the annual budget was invested on a combination of marketing and quality according to the marketing growth requirements. By 1992 the difference in market development for the 3 scenarios was significant. (Table 1)

Graph	Cumulative Diffusion (%)
a	57
b	27
c	90

Table 1

Greater cumulative adoption could have been achieved with the strategic use of price reductions, but for simplicity only two influences were used to give an indication of the type of results that could be produced.

This type of model could be used to explore a number of possible future scenarios. It is not a predictive device but can lend insight into the impact of different investment strategies.

Impact of Price

So far, analysis has been based on the actual historical purchase price of fax machines. Figure 8 shows results of varying the purchase price. Graph (a) was modelled using the actual historical purchase price. Graph (b) was modelled assuming a significantly reduced initial purchase price.

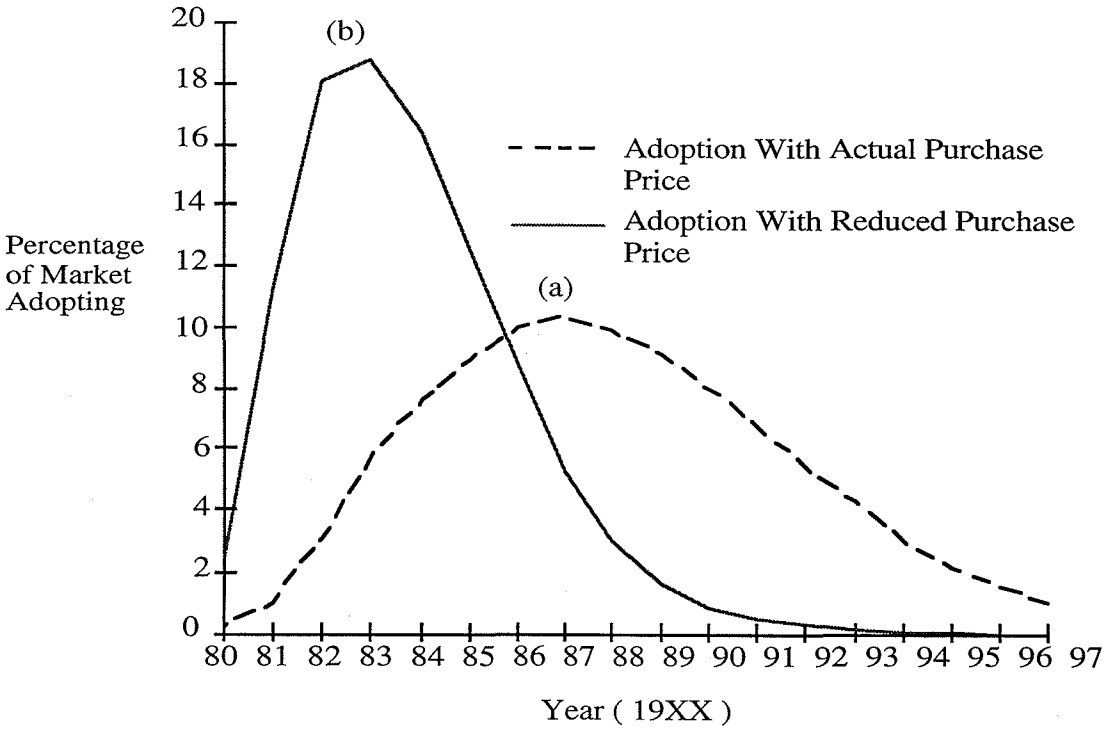


Figure 8: Graph of adoption versus time with variation in purchase price

Let us assume that one organisation controls the fax market and the network over which fax messages are sent. The impact of lowering the initial purchase price can be seen in Figure 8. The peak of annual adoption has moved from 10% of the market adopting in 1987 to approximately 20% of the potential market adopting in 1983.

Reducing the purchase price sharply would have adverse effects on the returns from unit sales. However, a substantial increase in returns from usage as a result of the increased size of the fax base could offset this.

If, in addition to reducing the purchase price, a strategy for maximising adoption of fax machines had been applied, then 79% of the potential market would have adopted fax machines by 1987.

The impact of price components

The model has been further modified to illustrate how different customer groups react to elements of the pricing package. Two hypothetical customer types have been profiled, corresponding loosely to residential and business customers for mobile services.

It is perceived that each customer group is differently sensitive to one off charges, such as the cost of the handset, and usage based charges such as call charges. By estimating the price elasticity of demand function for each element of price and customer, it is possible to examine how price discrimination strategies affect total revenue across both customer bases. Figure 9 indicates the relative revenues associated with the three different strategies.

Scenario C is the preferred outcome and represents a tailored offering for each customer group: low one off charges and moderate usage based charges for residential customers; higher one off charges but lower usage based charges for business customers. Scenario B is the revenue associated with a single set of prices for both markets.

Scenario A illustrates the impact of lowering prices too dramatically. Increase in demand is stimulated, but the volume increase multiplied by the reduced prices results in lower total revenue.

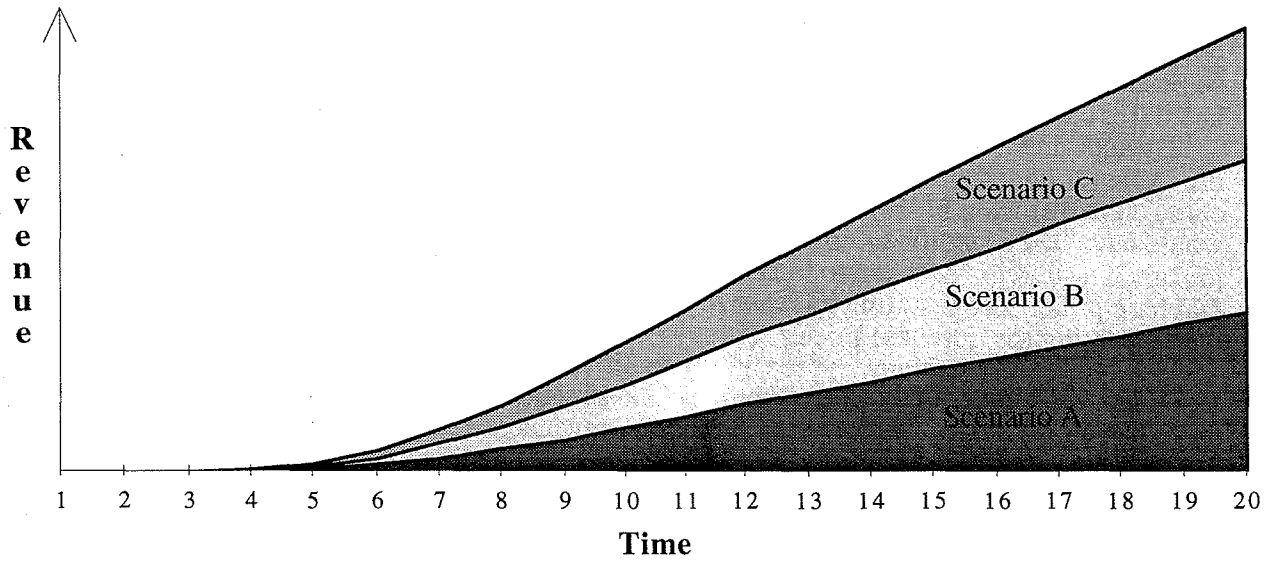


Figure 9: Graph of total revenue in arbitary units from two markets over time

Discussion

Areas for further work include consideration of effects due to resource constraints. Stimulating maximum demand growth, by investment or pricing initiatives, may not necessarily be optimal if there are supply limitations. For example, reducing the price of a fax machine in order to significantly increase the fax base, would not be appropriate if supply could not satisfy the resultant increase in demand. In addition, cost structures may significantly effect product profitability at differing levels of output.

System externalities have not been considered in this work (although taken from the point of view of the postal service, the effects of the postal strike on fax service can be viewed as an externality). Further study could incorporate a consideration of their effects on customer choice, and when data are available, analyse them within the context of geographical, business type and other factors.

Future work will apply this approach to the adoption of other products and services. Innovative services requiring the use of new terminal equipment, operating procedures and tariffs may exhibit similar behaviour to fax. In this context, video on demand and other innovative broadband services may be applicable. Understanding the potential growth of such new services will be critical to their deployment.

Modelling pricing elements and strategies will continue and the model will be validated against historic data for mobile services. It is intended to model a multi-product, multi-market environment to investigate cross elasticities of demand, and thus cross portfolio effects, of substitutable services. It is intended that this will give an insight into service portfolio management. Customers may be induced to take up new products and relinquish substitutes that are towards the end of their lifecycle by taking appropriate investment and pricing decisions.

Conclusions

This paper presents an analysis of product life cycles from the perspective of the customer's decision making process. The influences acting on this process have been represented by a number of factors including utility, quality and marketing expenditure. This approach has been validated using historical data on fax sales in the UK. The model produced an acceptable plot of calculated annual adoption compared to actual annual adoption, including the impact of a one off external event, the 1988 UK postal strike.

The effect of varying the influence of a number of factors has been investigated. These represent potential commercial strategies that a telecommunications service provider may employ. It has been demonstrated that different strategies may result in different product life cycles. It may be postulated that a service provider could have significantly changed the product life cycle for fax had it, for example, instituted an early price reduction.

By applying a number of scenarios to the annual investment of marketing and quality a product life cycle for adoption of Group 3 fax was produced. This product life cycle produced 90% cumulative diffusion by 1992 and was approximately 40% greater than actual diffusion. This would have had a significant impact on revenues. Further analysis of the model investigated the impact of a strategic decision to increase the fax base by significantly reducing the fax machine purchase price. The resulting increase in fax usage revenue was found to be greater than the cost of discounting the purchase price.

The model demonstrates the sensitivity to different elements of the overall price of a service. Initial work has shown that price discrimination strategies can enable a service provider to exploit different customer price sensitivities to increase revenues.

The model allows the user to explore a range of possibilities, assess their impacts and analyse commercial strategies. This technique has considerable potential for helping service providers to develop a range of product or service launch strategies. These can then be analysed to ascertain which have desirable outcomes in terms of percentage adoption and revenue.

References

Baker, M. 1986. *Marketing Strategy and Management*, Macmillan.

Barnes, J. Burton, F. Hawker, I. and Lyons, M.H. 1994.*Scenario Modelling of Demand for Future Telecommunications Services*, International System Dynamics Conference, Stirling, UK.

Bass, F. 1969.*A New Product Growth Model for Consumer Durables*, Management Science, Vol. 15, pp 215 - 227.

Catry, B. and Chevalier M. 1974.*Market Share Strategy and the Product Life Cycle*, Journal of Marketing, Vol 38, pp 29-34.

Dataquest Europe Limited. 1993.*Facsimile - Market History and Forecasts,*

Easingwood, C. J., 1988.*Product Life cycle Patterns For New Industrial Products*, R&D Management, Vol. 18, pp 23-32.

Forrester, J. W. 1965.*Industrial Dynamics,* MIT Press.

Howard, J. 1981.*The Empirical Theory of Managing the Market.* In: *Review of Marketing*, (D Shawyer, ed.), USA, American Marketing Association.

Kotler, P. and Armstrong, G. 1994.*The Principles of Marketing*, USA, Prentice Hall, Chapter 11, pp 330-336.

Lynch, T. Skelton, S. and Lyons, M.H. 1994. *Strategic Analysis of Global Telecoms Service Provision,* International System Dynamics Conference, Stirling, UK.

Lyneis, J. 1994.*Tactical vs. Strategic Approaches to Competitive Positioning -- An Example from the Telecommunications Industry,* International System Dynamics Conference, Stirling, UK.

Onkvisit , S. and Shaw J. 1986.*Competition and Product Management: Can the Product Life Cycle Help?*, Business Horizons, pp 51 - 62, July-August.

Quails, Olshavsky and Michaels, 1981. *Shortening of the Product Life Cycle - An Empirical Test,* Journal of Marketing, Vol. 45, pp 76 -80.