What Role can Growth Curves Play in Forecasting with Particular Reference Technology Strategy?

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Abstract

Previously, papers have been presented to the IWCS which have looked at the use of a limited set of equations to help predict the path of technology. The results were promising and indicated that a set of biologically inspired equations providing analogies for technology push, consumer pull and 'me too' type self fuelling growth had potential in predicting (a) the maximum speed etc. of a technology or maximum size of a market (b) the point at which a replacement technology should be invested in (c) understanding the market dynamics driving a technology. Currently an interview-based survey is underway to further investigate this hypothesis. This paper will present the preliminary results of this survey.

Keywords: Forecasting, growth curves, strategy.

1. Introduction

Technology driven industry is constantly evolving and market needs are continuously changing, as are the technologies required to satisfy them. Where industries experience a rapidly changing environment, it is crucial to be fully in command of developing and monitoring their technology strategy. As a contributor to this, it is important to understand whether a careful study of available, historical, market and technology data allows predictions to be made of future technological changes. Technology forecasting is this discipline and it aims to assist companies in identifying market and technology strategies and developing better policies.

The aim of this paper is to provide some evidence to help answer the question *'can a small set of biologically inspired growth curves provide a sufficient set of analogies to market conditions to allow companies involved in the communications infrastructure market to take historical data and make sufficiently accurate predictions of the future to successfully inform the development of their technology strategy?'* However, in order to add the necessary context to this question, there is a need to understand current practice and attitudes to forecasting within the communication cable industry.

This paper is based on a pilot study of managers' approaches to the development and planning of relevant technology strategy, their understanding of market drivers for several technologies and how this understanding allows the appropriate growth curve to be selected based on the concepts of market pull, technology push and self fuelling growth.

This study has concentrated on the communications cable industry, both metal and optical cabling. This is an industry with a long history of satisfying evolving telecommunications and, latterly, data-dense multimedia applications; it is an industry with high production costs and operates in a market where the customer requirements are constantly evolving. Hence, it is highly likely that forecast knowledge is of paramount importance to these organizations.

Telephone interviews were carried out with an expert sample of senior managers in the communications cable industry to ascertain their forecasting requirement and expectations in developing and implementing their technology strategy.

This paper provides a brief review of the current context of the communications cable industry, reviews the role of forecasting, including specific quantitative forecasting approaches, introduces the survey and analyzes the results.

2. The communication cable industry – post-downturn

It is well known to all in the industry that recent years have seen particular challenge and, like all similar financially trying times, some companies did not manage to survive. Consolidation has occurred in the market and some organizations have emerged strong. One commentator, speaking in 2009 said [1] *"we have every reason to believe that our industry will continue to be resilient and grow…and say that we have a central role to play in our economic recovery as well"*. A further comment was made to say that innovation is a strong point in this market and *'the cable industry should attempt to ensure it is allowed to grow unfettered'*. Finally, [1] noted that Commerce Secretary Gary Locke stated *"The advent of broadband and cable and all variants of telecommunications is the next great economic development that will rival electrification of rural America"*. He went on to say that *"when we think about the opportunity of broadband, I don't think any of us really understand the full potential of this technology."* Clearly, being able to plan ahead and anticipate applications and changes could make the difference between being one of those companies that thrives through adverse circumstances and one that fails.

3. The role and process of forecasting

It is worth considering that *"forecasting methods serve to predict future events and conditions and should be key decision making elements"* [2]. There are various qualitative and quantitative techniques available to organizations looking to forecast technological development and markets [3].

A previous study [4] suggested that a closed set of three biologically inspired growth equations. The following section summarises these equations and the following section applies them to some sample data.

3.1 Growth equation

Many growth phenomena in nature and in technology can be described by an "S" shaped (sigmoidal) pattern, with initially slow growth speeding up before slowing down to approach a limit. For example, considering the sales of a new product, this could be explained as three different stages:

- Incubation: initially, sales increase slowly
- Rapid growth.
- Maturity: There is a growth reduction because the market is saturated or close to saturation .

These stages are not perfectly defined, they could change depending on a variety of factors, such as the market, technology, the economy, the competitive landscape, speed and veracity of adoption, improvements in performance and cost. There are several equations to describe that sigmoidal shape and every stage depends on the model chosen for the study.

It was proposed in [4] that a limited set of such growth equations can provide a useful but limited and therefore manageable set of drivers by which the technology or market development can be explained. It was suggested that simple analogies can be used so that:

- The Fisher-Pry (Logistic) curve describes technology push behavior.
- The Gompertz curve describes consumer pull behavior.
- The Morgan-Mercer-Flodin (MMF) curve describes self fuelling growth.

Previous studies on some of these growth curves suggested that they can be accurate with very early data [3].

The Logistic curve can be described using equation (1)

$$y = \frac{c}{1 + ae^{-bt}}$$
(1)

y is the parameter being modeled, t is the independent variable (e.g. time) and a, b and c are parameters that determine the shape of the curve.

The Gompertz curve can be described using equation (2)

$$y = ce^{-e^{-b(t-a)}}$$
(2)

where y is what being modeled, t is the independent variable (e.g. time, as above) and a, b and c are parameters that determine the shape of the curve and they means respectively the time of maximum growth, the growth rate and the upper asymptote.

The Morgan-Mercer-Flodin (MMF) curve is described using equation (3)

$$y = \frac{a \cdot b + c \cdot x^d}{b + x^d}$$
(3)

3.2 Examples

3.2.1 Ethernet Technology

Figure 1 reproduces some information freely available on the internet discussing 10gigabit Ethernet manufacturers' revenue. Applying the three curves above to this data predicts that if a technology push is to be assumed then the maximum annual revenue will be $5.8 billion, reaching this value in 2013. However neither the Gompertz nor the MMF curve fit with such early data. Indicating that the early adoptions have been

manufacturer 'push'. However, approaching this from a slightly different angle, i.e. that of the number of installed ports, forecast data from [5] suggests that the three equations will give rise to the following numbers of installed ports.

- Logistic: 96.5million, saturated by 2019
- Gompertz: 112.5 million, saturated by 2021
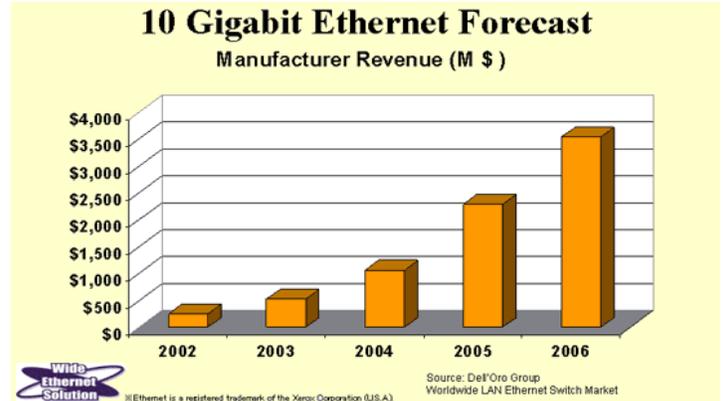- MMF: 115 million, saturated by 2027

Fig. 1 Projections of 10Gb Ethernet revenue

Clearly, choosing the right model is vital for future planning. It should also be noted that, for the purpose of this exercise the assumptions underpinning the forecast on which these models are based, are assumed to be flawless. The two different approaches to analyzing the problem suggest that a pure 'industry push' will see 10Gb Ethernet becoming obsolete within the next few years. If we assume that a consumer pull model dominates then 10 Gb Ethernet will replace and upgrade existing services in the early years of the 20s. If, however, the existence of 10Gbit Ethernet gives rise to other applications that are sought on a 'me too' basis by other consumers then the market is likely to be buoyant for approximately 15 more years.

3.2.2 Business internet traffic

Cisco predicted that the global business IP traffic (in PB per month) would be 3103 in 2008 rising to 12833 in 2013 [6]. Applying the three curves predicts:

- Logistic 37000 PB/month by 2030
- Gompertz 350000 PB/month by 2060
- MMF 130000 PB/Month by 2060

This may be clearly an indication that monitoring the traffic levels will give an indication in a very few years whether one or other models dominates.

These two examples will be used as part of the analysis of the interview survey of a number of managers in the wire and cable industry.

4. The survey

There are two complementary aspects to the survey being reported in this paper. Firstly, it is instructive to understand the similarities and/or diversity of managers' attitudes to the use and practice of forecasting, particularly using quantitative methods. Secondly, with their understanding of the markets which are serviced by communications infrastructure, can a consensus be formed about the drivers of various technologies to identify the

likely forecasting curve, thereby suggesting an upper bound to that technology.

For the preliminary study reported here, interviews were conducted with seven managers. All were selected because of holding senior management positions in their own organizations and their long standing involvement with the IWCS and hence their interest in the industry as a whole.

The questions asked of the managers was:

1. How many years do you look ahead in forecasting?
2. Do you use historical, market or technology based, data as part of your strategic technology forecasting?
3. What sources do you use for forecasting?
4. How do you validate or cross check the accuracy and 'believability' of this data?
5. Do you use any mathematical modeling system for forecasting?
6. What role does forecast data plays at each of the four stages of strategic decision making.
   a. Is forecast data used as input to the "Setting of Objectives" stage?
   b. Is forecast data used as input to the "Analysis of Options" stage?
   c. Is forecast data used as input to the "Selection and Formulation of Strategy" stage?
   d. Is forecast data used as input to the "Implementation and Control" stage?
7. Are you satisfied with available data for forecasting decision?
   a. Which data would you like/need to have in forecasting process?
8. What is your view on the following specific scenarios:
   a. What factors do you think are driving the growth in 10Gigabit Ethernet manufactures revenue?
   b. What do you think are the key factors driving increase in internet traffic for business?
   c. Considering the impact of the financial crisis that hit in 2009, how would you say the forces that control worldwide carrier Ethernet revenue have changed from you view of it before and after the crisis hit?
   d. Do you think that internet advertising is on the rise or fall (from 2008) and if so why?

The answers to questions 1 – 7 help to address the similarity or diversity of attitudes to forecasting and question 8 provides qualitative evidence to inform quantitative analysis.

5. Results

There was a reassuring level of agreement between the respondents to many of the questions. This section summarises those responses.

5.1 Question 1

The range of responses was between 3 and 10 years. The most common answer was five years. One respondent said that the time horizon for new products is 3-5 years and for existing products the horizon is 5-7 years. It would be fair to say that the forecasting horizon looks forward up to 10 years but five years is a comfortable period in which to plan new products, maintain existing products and plan for the withdrawal of products. One factor in setting the forecasting horizon was the length of time from a requirement coming to into standards making process and the completed standard.

5.2 Question 2

Many of the managers used data and analysis supplied by third party research organizations (such as CRU) and triangulated this internally by looking at how the data fits their knowledge of the market history and dynamics. Very little 'sophisticated' mathematical analysis is undertaken on the data other than trend analysis using simple extrapolation and regression. There was a general view in the discussions indicating that many of the managers would welcome additional approaches to mathematically modeling the data but either they or their marketing departments did not feel they had the time to investigate this properly or the resource to allocate. There was also a feeling that the techniques used so far were adequate (but it should be remembered that the organizations polled for this survey were those which had satisfactorily weathered the recent economic adversity).

5.3 Question 3

Widely used sources are the various market reports available (e.g. Forrester). The use of informal and formal environment monitoring was also widespread. This was based on manucfacturers' discussions with customers, suppliers, complementary industries and colleagues in the same industry (often through participation in standards activities). As, indeed was, the pool of knowledge already contained within the organization based on modeling from previous projects and an understanding of market dynamics garnered from historical data.

5.4 Question 4

There were some common themes in answer to this question. Organizations would use multiple sources of data and triangulate these. They would look back at predictions made for the previous year and compare them with actuality. One respondent made the point that they would make a judgment on a market analyst by asking what that analyst knows about their own company. Clearly, none of the respondents took external data simply at face value and looked to validate and cross check where possible, including comparing actual performance with predicted performance over a given period. One respondent said that they would look at the assumptions made in making the forecast and they test whether the assumptions made were generally held true by other managers. If there are any disagreements, they would modify the forecast. In a similar approach to ensuring that the forecasts were used wisely in an organization, one respondent said that the forecast data would be used as part of a scenario analysis exercise.

5.5 Question 5

As discussed in a previous question, generally, only simple extrapolation and regression-type models were used. It is thought that one reason for this is that the marketing teams responsible for analyzing the forecasts may not have the experience, desire or knowledge to investigate the use of more sophisticated techniques.

5.6 Question 6

It seems that forecast data is universally used in setting objectives, in particular, with making operational decisions such as capacity planning, deciding on staffing levels, as well as strategic decisions such as product return on investment. Further along the strategic decision making chain the use becomes more a factor supporting the monitoring of those decisions. One respondent used forecast data to monitor scenario analysis.

5.7 Question 7

There was some ambivalence to this question. Several respondents said that they were not satisfied and would like to know if there is more accurate forecast data. On the other hand, there was the acknowledgement that there may not be other sources of data.

The second part of the question did generally agree that better knowledge of the size of markets would be beneficial. One respondent noted the importance of obtaining information about factors influencing related industries.

5.8 Question 8

5.8.1 Question 8(a)

There was a clear agreement that virtually all data-based applications require more data and, for example, more video so there is a strong drive to accommodate this and provide the necessary available bandwidth. Not only is this an industrial phenomenon because of the need for more data to be shared around the world in real time but it is also a domestic/consumer phenomenon with the advent of smart phones and video rich applications. When asked what is driving the desire for more data, a theme was that often there will be followers in the market who will purchase equipment because others already have it. It was noted that the 'on demand' aspect of the market will continue to increase demand for high bandwidth connectivity.

5.8.2 Question 8(b)

Respondents agreed that there are many industrial applications requiring high data throughput, typically, real time collaboration involving detailed drawings and video conferencing of a globalized workforce where the database is centralized but with several mirror servers. One respondent noted that the creation of bandwidth is like the creation of arterial roads: "if you create bandwidth, it will be used".

5.8.3 Question 8(c)

There was an interesting array of answers to this question. One suggested that the post-crisis economy was paying more attention to e-commerce because efficiency and cost management are the keys to future success. Others also suggested that the post-crisis economy was focusing on infrastructure with one respondent saying that their company is seeing heavy demand in all segments and that they are struggling to meet that demand.

5.8.4 Question 8(d)

Here again, there were a range of opinions as to drivers. All agreed that internet advertising was on the rise. One respondent said that he cannot see the limits to this. Two respondents noted that there wass also an element with internet advertising that it is replacing newspaper advertising.

6. Discussion

This can only be considered a pilot study because of the numbers of interviewees involved. However, there are a number of consistent themes coming out of the interviews, which may well be representative of the industry. Participation in standards activities was considered important by many of the respondents.

Forecasting is important at all stages in a product lifecycle, particularly at the early stages of any product introduction (and also the latter stages). Much of this information comes from external market research sources but the companies involved all treated that intelligence as part of a more rounded approach to understanding the markets. In particular, they would seek other internal and external data to triangulate the predictions and would sometimes seek to look at predictions retrospectively to test their accuracy.

In no case was mathematical analysis used on quantitative data, except for relatively straightforward extrapolation or regression analysis. However, a desire for better intelligence, as it relates to market size and segmentation, in particular, was a commonly held view.

It is instructive to look at the responses to the scenario questions in an attempt to see how commonly held views about the dynamics of a market can help in the prediction of the progress of that market. It has been assumed that three commonly occurring market drivers are consumer pull, industry push or 'me too' self fueling growth and that these can be modeled by the biologically inspired growth curves representing mortality (Gompertz), replacement (Logistic) and the growth of a biological system (Morgan-Mercer-Flodin) equation. A question to ask here is what intelligence can be gained from applying those equations to the scenarios previously discussed.

The answers to question 8(a) initially suggested that the driving force here was customer adoption (which would suggest a Logistic curve). However, further questioning suggested that there may be an element of self fueling growth in this market. The forecast analysis presented earlier provides maximum values that are not hugely different and occur at the limit of or outside the normal forecasting window used by the companies.

The overall feeling from the answers to question 8(b) is that self-fueling growth is the motivator for this market development. If that is a correct assumption, organizations could plan for a steady growth in traffic up to approximately 130000 peta Bytes per month over the next generation.

In addressing question 8(c), it is interesting to note that the consensus view is that the post-crisis economy is more focused on a consumer pull as there is a notable concentration on infrastructure.

Question 8(d) was asked because it is unlikely that any respondent will be expert in advertising revenues but will have experience in using various advertising media. No one doubted the ascendency of internet advertising and it was suggested that print-media is being replaced by electronic sources. This is generally borne out by data [7]: in 2008 US print (newspaper and magazine) expenditure was $180B and will decline to $140B in 2012, whereas internet expenditure was $49B in 2008 and will rise to $77B in 2012 with very little change in the overall expenditure.

7. Conclusions

The overall purpose of the work that this paper forms part of is to identify the circumstances under which various sigmoidal growth curves can be applied and whether the proposed analogies are pertinent. This paper has presented some of the preliminary information related to the the way in which the wire and cable industry approaches forecasting. It noted that external, third party, data is very important: particularly when triangulated against other primary or secondary intelligence. However, data analysis adopting more sophisticated techniques than simple extrapolation or regression analysis is not applied. Never-the-less many of the managers interviewed said that they would like access to additional intelligence.

Some analysis has been provided in this paper associated with some of the scenarios. As much as the data itself can be helpful, it should be remembered that the act of criticizing and analyzing those projections and the ensuing challenge of the underlying assumptions can provide invaluable additional intelligence to any 'Learning Organisation'

Acknowledgement

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Leda Cesta was born in Roseto degli Abruzzi, Italy, in 1984. She obtained a Bachelor's degree in Managerial Engineering from L'Aquila University in 2008 working on a project in a company on aluminium coat. She worked on this project in Leicester University. It will be the thesis work for her second degree in Engineering Management. She is completing her studies focusing on management of technological processes and industrial data transfer.