Forcasting the Sales of New Products and the Bass Model

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Types of New Product Situations

- A new product is introduced by a company when a favorable estimate has been made of its future sales, profits, and other impacts on the firm's objectives.
- The appropriate sales-forecasting model varies with the type of new product situation
  - the degree of newness of the product
  - the degree of product repurchassability.

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Product Newness

Company		Market: New	Market: Not New
	New	New Product Innovation	New Brand
	Not New		New Model

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Frequency of Purchase

Products that buyers are likely to purchase

- only once, until it needs to be replaced (durable)
- occasionally (automobile tires)
- frequently.

All new products must be adopted by a purchasing population who initially do not know about them.

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The Adoption Process for New Products

The diffusion of innovations: how a new idea, a good, or a service is assimilated into a social system over time.

The *diffusion process* is the spread of an idea or the penetration of a market by a new product from its source of creation to its ultimate users or adopters.

The *adoption process* is the steps an individual goes through from the time he hears about an innovation until final adoption (the decision to use an innovation regularly).

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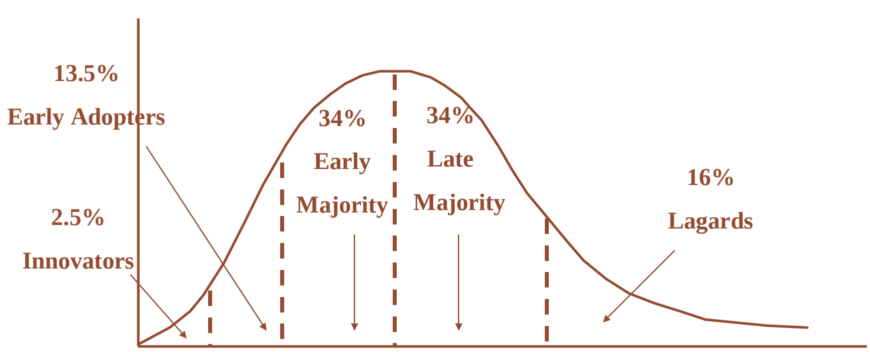
The Innovativeness

The difference among individuals in their response to the new ideas is called their ***innovativeness:*** the degree to which an individual is relatively early or late in adopting a new product or idea.



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Diffusion Models

- A diffusion model produces a life-cycle sales curve based on a small number of parameters.
- The parameters may be estimated:
  - by analogy to the histories of similar new products introduced in the past
  - by early sales returns as the new product enters the market.
- The most important diffusion model is the Bass model:

Bass, F. 1969, "A new product growth model for consumer durables," *Management Science*, Vol. 15, no. 4, pp. 215-227.

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Overview of the Bass (1969) Model

- It is appropriate for forecasting first purchase of a new product for which no closely competing alternatives exist in the marketplace.
- Managers need such forecasts for new technologies or major product innovations before investing significant resources in them.
- The Bass model offers a good starting point for forecasting the long-term sales pattern of new technologies and new durable products under two types of conditions:
  - the firm has recently introduced the product or technology and has observed its sales for a few time periods; or
  - the firm has not yet introduced the product or technology, but it is similar in some way to existing products or technologies whose sales history is known.

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The Bass Model

Model designed to answer the question:

How many customers will eventually adopt the new product and *when*?

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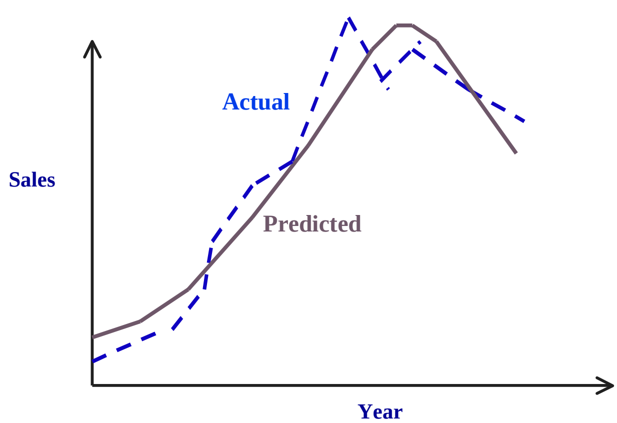
Actual sales and predicted sales for room air conditioners (1947-1961)



A simple and elegant model (Bass 1969) with just three easily interpretable parameters can represent the sales trajectory quite well.

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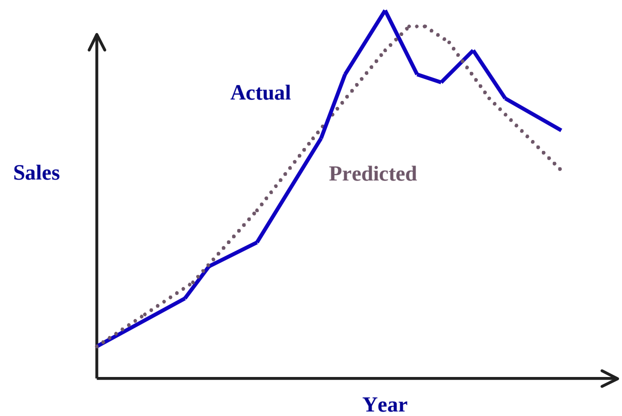
Actual sales and predicted sales for clothes dryers (1950-1960)



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Assumptions of the Basic Bass (1969)Model

- Diffusion process is binary (consumer either adopts, or waits to adopt)
- Constant maximum potential number of buyers (*m*)
- Eventually, all *m* will buy the product
- No repeat purchase, or replacement purchase
- The impact of the word-of-mouth is independent of adoption time
- Innovation is considered independent of substitutes
- The marketing strategies supporting the innovation are not explicitly included

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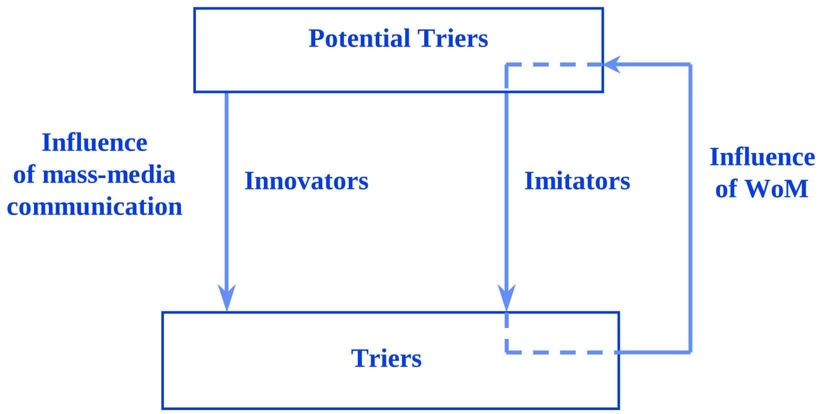
Innovators and Imitators



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The Mathematical Formulation of the Bass Model

Let

p= Coefficient of innovation (or coefficient of external influence)
q=Coefficient of imitation (or coefficient of internal influence).

Then

Number of customers who will purchase the product at time *t*	=	*p* x Remaining Potential	+	*q* x Adopters x Remaining Potential
		Innovation Effect		Imitation Effect

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The Mathematical Formulation of the Bass Model cont'd

More exactly, if

$N(t)$ = Total number of adopters of the product up to time t

m = Total number of potential buyers of the new product

Then the number of customers who will purchase the product at time t [= $n(t)$] is equal to $dN(t)/dt$

The effect of the mass-media on potential triers (generation of innovators)

The effect of the WoM on potential triers (generation of imitators)

$$n(t) = dN(t)/dt = p\,[m - N(t)] + \frac{q}{m} N(t)\,[m - N(t)]$$

The triers at time t

The potential triers

$$= [p + \frac{q}{m} N(t)][m - N(t)]$$

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Solving the Bass Model

$$dN(t)/dt = [p + (q/m)N(t)][m - N(t)], \quad N(0) = 0$$

Cumulative number of adopters $\quad N(t) = m \dfrac{1 - e^{-(p+q)t}}{1 + \frac{q}{p} e^{-(p+q)t}}$

Noncumulative number of adopters $\quad n(t) = dN(t)/dt = m \dfrac{p(p+q)^2 e^{-(p+q)t}}{[p + qe^{-(p+q)t}]^2}$

Time of peak adoptions $\quad T^* = -\dfrac{1}{p+q} \ln \frac{p}{q}$

Number of adopters at the peak time $\quad n(T^*) = \dfrac{1}{4q}(p+q)^2$

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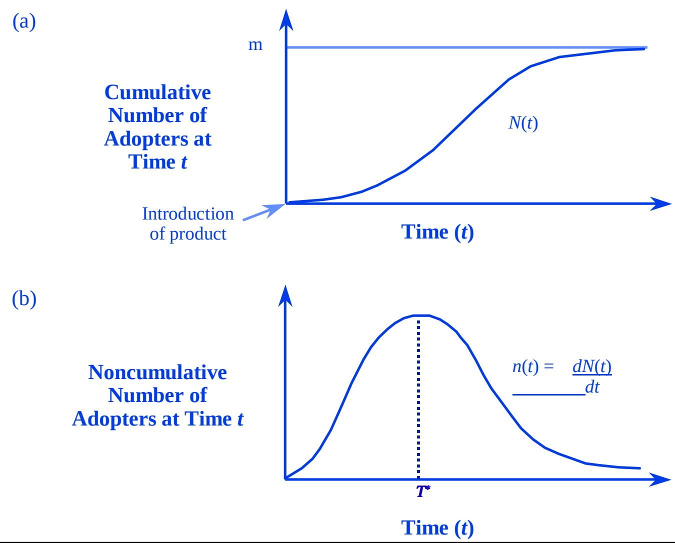
Cumulative and Noncumulative Number of Adopters over Time



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Two Cases: $T^* = -\frac{1}{p+q} \ln \frac{p}{q}$

q>p --> T*>0

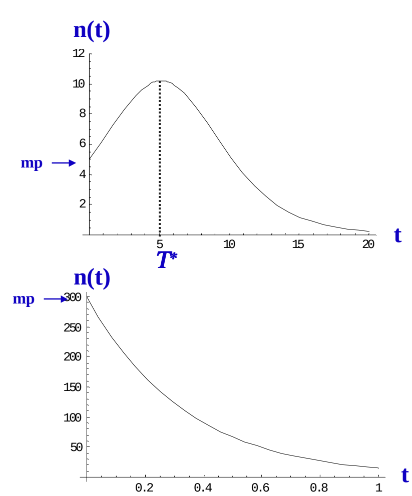
A successful product:

the influence of WoM is greater than the external influences

q<p --> T*<0

A unsuccessful product:

the influence of WoM is smaller than the external influences



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Estimating the Parameters of the Bass Model Using Non-Linear Regression

An equivalent way to represent $N(t)$ in the Bass model is the following equation:

$$n(t) = \left[p + \frac{q}{m} N(t-1) \right] [m - N(t-1)]$$

Given four or more values of $N(t)$ we can estimate the three parameters of the above equation to minimize the sum of squared deviations.

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Parameters of the Bass Model in Several Product Categories

Product/ Technology	Innovation parameter (p)	Imitation parameter (q)
B&W TV	0.028	0.25
Color TV	0.005	0.84
Air conditioners	0.010	0.42
Clothes dryers	0.017	0.36
Water softeners	0.018	0.30
Record players	0.025	0.65
Cellular telephones	0.004	1.76
Steam irons	0.029	0.33
Motels	0.007	0.36
McDonalds fast food	0.018	0.54
Hybrid corn	0.039	1.01
Electric blankets	0.006	0.24

A study by Sultan, Farley, and Lehmann in 1990 suggests an average value of 0.03 for p and an average value of 0.38 for q.

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Forecasting Using the Bass Model—Room Temperature Control Unit

Market Size =16,000

Innovation Rate = 0.01
(Parameter p)

Imitation Rate = 0.41
(Parameter q)

Quarter	Sales	Cumulative Sales
0	0	0
1	160	160
4	425	1,118
8	1,234	4,678
12	1,646	11,166
16	555	15,106
20	78	15,890
24	9	15,987
28	1	15,999
32	0	16,000
36	0	16,000

Example computations

$$n(t)=[p+(q/m)N(t-1)][m-N(t-1)]=pm + (q-p)\,N(t-1) - qN^2(t-1)/m$$

Sales in Quarter 1 = 0.01 X 16,000 + (0.41–0.01) X 0 – (0.41/16,000) X $(0)^2$ = 160

Sales in Quarter 2 = 0.01 X 16,000 + (0.40) X 160 – (0.41/16,000) X $(160)^2$ = 223.35

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Some Extensions to the Basic Bass Model

- Robinson and Lakhani (1975)

Incorporating the effect of price on the sales rate:

$$dN(t)/dt= [p +(q/m_0)N(t)][m_0 - N(t)]g(P(t))$$

P(t) - the price at time t

The price controls the rate of adoption

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Feichtinger (1982)

- Varying market potential as a function of product price

$$dN(t)/dt = [p + (q/m(P))N(t)][m(P) - N(t)]$$

for example:

$$m(P)=m_0 e^{-aP}$$

This extension is suitable to repeat purchases

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Horsky and Simon (1983)

- Incorporation of marketing variables
  - Coefficient of innovation (p) as a function of advertising

$$p : a + b \ln A$$

$$dN(t)/dt = [a + b \ln A + (q/m)N(t)][m - N(t)]$$

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Kalish (1985)

- Varying market potential as a function of product price, reduction in uncertainty in product performance

  $m=m(P/u)$ and $u=u(N(t)/m_0)$

  - ***P*** is the price
  - ***u*** is the uncertainty which is proportional to the numbers of cumulative adopters

- Multi-stage diffusion process

  Awareness ➨ Adoption

  - Awareness is a diffusion process

Percentage of non-aware people

$$dI(t)/dt= [f(A)+q_1(I-N(t)/m_0) +(q_2/m_0)N(t)][1 - I(t)] \qquad (1)$$

Coefficient of innovation as a function of advertising

Percentage of triers (and aware)

Percentage of non-triers and aware people

  - Adoption depends on awareness

$$dN(t)/dt= k[m(P/u)I(t)-N(t)] \qquad (2)$$

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Example of Using Kalish

$$m(P/u)=m_0e^{-aP/u}$$

$$u=[(b+(N(t)/m_0)^2]/(b+1) \quad \text{-->} \quad 0<u<1$$

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Generalized Bass Model

Bass, F., Krishnan, T. and Jain D. 1994, "Why the Bass model fits without decision variables," *Marketing Science*, Vol. 13, no.3, p.203-223.

Incorporate the effect of marketing-mix variables:

$$dN(t)/dt = [p + (q/m_0)N(t)][m_0 - N(t)]x(t)$$

where $x(t)$ is a function of marketing-mix variables in time period t (as advertising and price)

➨ Marketing efforts speed up the rate of diffusion of the innovation in the population.

In the software marketing effort is measured relative to a base level indexed to 1.0.

For example: if advertising at time t is double the base level, $x(t)$ will be equal to 2.0.

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Generalized Bass Model Software

- It is an Excel model to forecast the adoption of new products.
- It implements the original Bass (1969) as well as the extended version Bass, Krishnan and Jain (1994) (including the effects of advertising and price changes).
- The software provides two modes for calibrating the model:

  (1) by analogy

  there is a data base that contains actual data points, estimated p and q coefficients, and estimates of market potential for various data sets to which Bass model was applied

  (2) by fitting the Bass model to past data via nonlinear least squares.

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Using Analogous Products

- It is a useful approach:
  - (1) identify previous innovations that are analogous to the current product
  - (2) determine *p* and *q* from the sales trajectories of the previous innovations and combine this with *m* for the current innovation (by managerial judgement).
- We must be careful in choosing the analogous products:
  - analogies based on similarities in expected market behavior work better than analogies based on product similarities
  - if necessary, we can consider multiple analogs and take the average (weighted).

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