Diffusion of innovations

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The study of the **diffusion of innovation** is the study of how, why, and at what rate new ideas and technology spread through cultures.

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Theories of innovation diffusion

French sociologist Gabriel Tarde originally claimed that sociology was based on small psychological interactions among individuals, especially imitation and innovation.

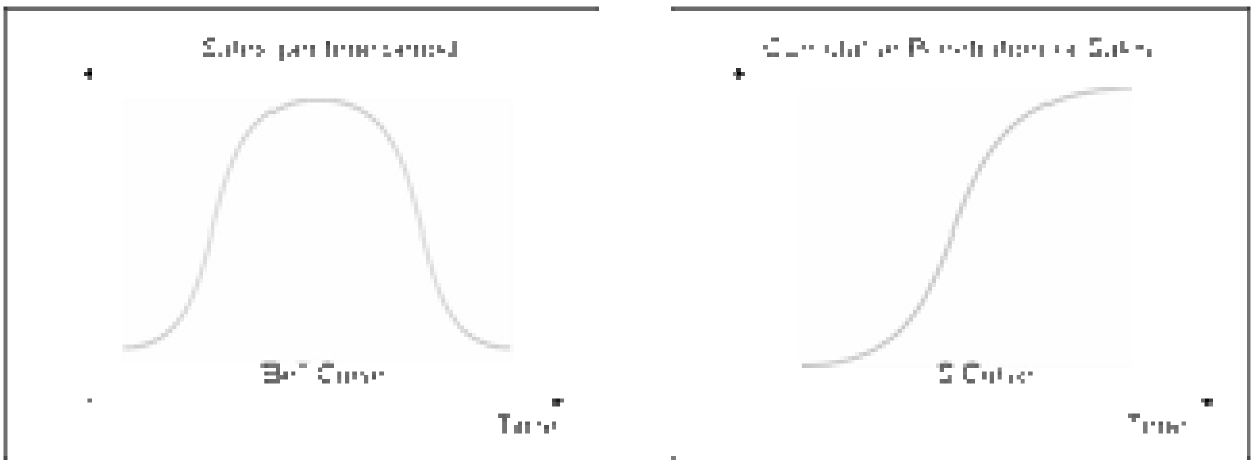
A first *theory of innovation diffusion* was formalized by Everett Rogers in a 1962 book called *Diffusion of Innovations*. Rogers stated that adopters of any new innovation or idea could be categorized as innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%), based on a bell curve. Each adopter's willingness and ability to adopt an innovation would depend on their awareness, interest, evaluation, trial, and adoption. Some of the characteristics of each category of adopter include:

- innovators - venturesome, educated, multiple info sources, greater propensity to take risk
- early adopters - social leaders, popular, educated
- early majority - deliberate, many informal social contacts
- late majority - skeptical, traditional, lower socio-economic status
- laggards - neighbours and friends are main info sources, fear of debt

Rogers also proposed a five stage model for the diffusion of innovation:

1. *Knowledge* - learning about the existence and function of the innovation
2. *Persuasion* - becoming convinced of the value of the innovation
3. *Decision* - committing to the adoption of the innovation
4. *Implementation* - putting it to use
5. *Confirmation* - the ultimate acceptance (or rejection) of the innovation

The S-Curve and technology adoption



The adoption curve becomes a s-curve when cumulative adoption is used.

Rogers theorized that innovations would spread through society in an S curve, as the early adopters select the technology first, followed by the majority, until a technology or innovation is common.

The speed of technology adoption is determined by two characteristics *p*, which is the speed at which adoption takes off, and *q*, the speed at which later growth occurs. A cheaper technology might have a higher *p*, for example, taking off more quickly, while a technology that has network effects (like a fax machine, where the value of the item increases as others get it) may have a higher *q*.

Caveats and criticisms

Critics of this model have suggested that it is an overly simplified representation of a complex reality. [*citation needed*]

A number of other phenomena can influence innovation adoption rates, such as -

1. Customers often adapt technology to their own needs, so the innovation may actually change in nature from the early adopters to the majority of users.
2. Disruptive technologies may radically change the diffusion patterns for established technology by starting a different competing S-curve.
3. Lastly, path dependence may lock certain technologies in place, as in the QWERTY keyboard.

See also

- Bass diffusion model
- Crossing the Chasm
- Cultural evolution
- Development communication
- Disruptive technology
- Dual inheritance theory
- Early adopter
- Logistic function
- Meme
- Path dependence
- Percolation
- Technology acceptance model
- Technology lifecycle
- TRIZ
- Two-step flow of communication

References

- Rogers, Everett M. (1962). *Diffusion of Innovations*.
- Rogers, Everett M. (2003). *Diffusion of Innovations, Fifth Edition*. New York, NY: Free Press. ISBN 0-7432-2209-1.

Research Results

Historical Perspective:
The Technology Adoption Lifecycle

The technology adoption lifecycle was originally developed in 1957 at Iowa State College. Its purpose was to track the purchase patterns of hybrid seed corn by farmers. Approximately six years later Everett Rogers broadened the use of this model in his book, *Diffusion of Innovations.*

The following psychographic profiles were abstracted from the North Central Rural Sociology Committee, Subcommittee for the Study of the Diffusion of Farm Practices. The Diffusion Process. Ames: Agriculture Extension Service, Iowa State College, Special Report No. 18, 1957

<u>Innovators</u>
They have larger than average farms, are well educated and usually come from well established families.They usually have a relatively high net worth and, probably more important, a large amount of risk capital. They can afford and do take calculated risks on new products. They are respected for being successful, but ordinarily do not enjoy the highest prestige in the community. Because innovators adopt new ideas so much sooner than the average farmer, they are **sometimes ridiculed by their conservative neighbors**. This neighborhood group pressure is largely ignored by the innovators, however. The innovations are watched by their neighbors, but they are not followed immediately in new practices.

The activities of innovators often transcend local community boundaries. Rural innovators frequently belong to formal organizations at the county, regional, state, or national level. In addition, they are likely to have **many informal contacts outside the community**: they may visit with others many miles away who are also trying a new technique or product, or who are technical experts.

<u>Early Adopters</u>
They are younger than the average farmer, but not necessarily younger than the innovators. They also have a higher average education, and participate more in the formal activities of the community through such organizations as churches, the PTA, and farm organizations. They participate more than the average in agricultural cooperatives and in government agency programs in the community (such as Extension Service or Soil Conservation). In fact, there is some evidence that **this group furnishes a disproportionate amount of the formal leadership** (elected officers) in the community. The early adopters are also respected as good sources of new farm information by their neighbors.

<u>Early Majority</u>
The early majority are slightly above average in age, education, and farming experience. They have medium high social and economic status. They are less active in formal groups than

innovators or early adopters, but more active than those who adopt later. In many cases, they are not formal leaders in the community organizations, but they are active members in these organizations. They also attend Extension meetings and farm demonstrations.

The people in this category are most likely to be informal rather than elected leaders. They have a following insofar as people respect their opinions, their "high morality and sound judgment." They are "just like their following, only more so." They **must be sure an idea will work before they adopt it**. If the informal leader fails two or three times, his following looks elsewhere for information and guidance. Because the informal leader has more limited resources than the early adopters and innovators, he **cannot afford to make poor decisions**: the social and economic costs are too high.

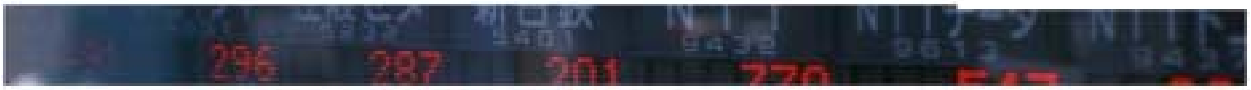
These people tend to **associate mainly in their own community**. When people in the community are asked to name neighbors and farmers with whom they talk over ideas, these early majority are named disproportionally frequently. On their parts, they value highly the opinions their neighbors and friends hold about them, for this is their main source of status and prestige. The early majority may **look to the early adopters for their new farm information**.

<u>Late majority</u>
Those in this group have less education and are older than the average farmer. While they participate less actively in formal groups, they probably form the bulk of the membership in these formal organizations. Individually they belong to fewer organizations, are less active in organizational work, and take fewer leadership roles than earlier adopters. They do not participate in as many activities outside the community as do people who adopt earlier.

<u>Laggards</u>
They have the least education and are the oldest. They participate least in formal organizations, cooperatives, and government agency programs. They have the smallest farms and the least capital. Many are suspicious of county extension agents and agricultural salesmen.

JUAN C. MENDEZ'S PAGES

JC's thoughts on business, technology and everything else



Modeling market adoption in Excel with a simplified s-curve

Apr 24th, 2007 by Juan C. Mendez

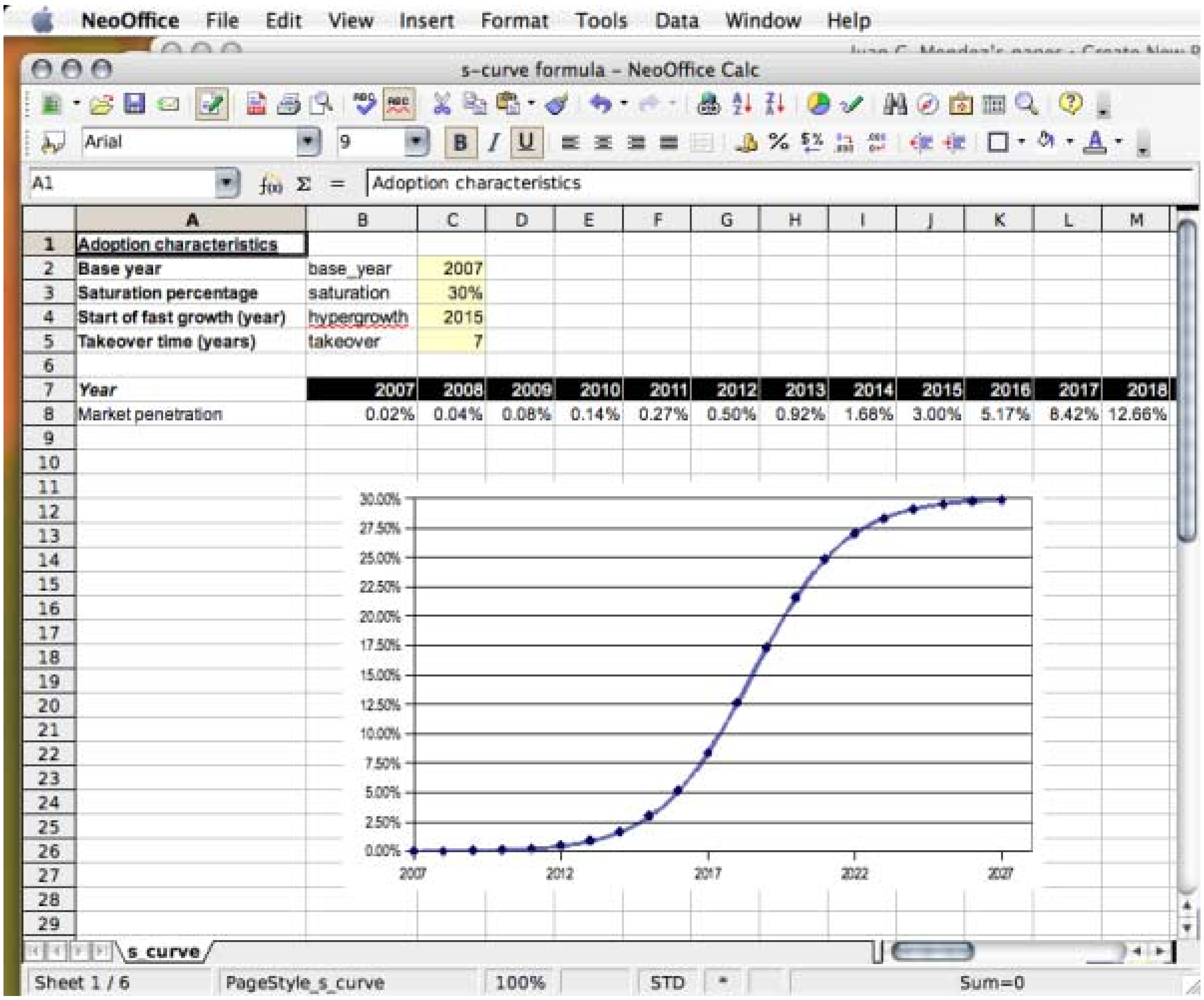
Often business analysts need to model the adoption of a new product or service for financial planning. There are several approaches, but a common one is the s-curve. Here is a simple implementation in Excel that can be easily added to your spreadsheets. It reduces all the math to just three parameters:

- **saturation** - What is the maximum expected penetration after the product becomes mainstream? i.e. what is the value that the top of the s-curve will reach?
- **start of fast growth** - By this year, the penetration will be 10% of the saturation value, and it will start to grow rapidly. 10% was an arbitrary choice to simplify the model, and by doing some math you could change the formula to any value. It is a reasonable choice in most cases. We'll call this parameter hypergrowth
- **takeover time** - How long it will take for the product to "catch on"? - The operational assumption in the formula is that this number of years after the start of fast growth, the product would have reached 90% of the saturation value and will start to slow down. Again, 90% is an arbitrary value I chose.

The s-curve model focuses in the early phases of the product lifecycle, until maturity is reached. Penetration decay is NOT covered by this model.

The formula for each year's penetration would simply be:
=saturation/(1+81^((hypergrowth+takeover/2-year)/takeover))

See it in action:



In the sample spreadsheet above, look at cell B8 where you can see the formula in use. It is the same for all row 8.

saturation, hypergrowth and takeover are names defined for the parameters on rows 2 to 5 (you use names in your models instead of plain cell references, don't you?)

Very simple, easy to maintain, light on calculation times… happy market adoption modeling!

PS: The chart shown is NeoOffice, an open source alternative to Excel for Macintosh users, based on OpenOffice

- 1 *Ken J*

Very nice. Simple and practical. I always get customers questioning the shape of the S curve and this is a great way to do it.

One question I have is 81. I assume you get to this based on your 10% in the first part of the tail. What do I use if I want 20% in the first part of the tail?

on 03 Jun 2007 at 11:15 pm 2 *Juan C. Mendez*

Ken - Thanks for your comment, and sorry for the late response. I had comment notifications off because of a recent slew of spam.
If you want an s-curve that reaches 20% (of the saturation value) in the first part of the tail (i.e. by the period denoted by the parameter hypergrowth), you can use 16 instead of 81 in the formula. Such curve will only reach 80% at the period hypergrowth+takeover, and it will look much “softer”. A “sharper” curve, that reaches 5% in the first part, grows and reaches 95% at hypergrowth+takeover can be obtained using 360 instead of 81.
Best regards, Juan C.

on 12 Jun 2007 at 3:33 pm 3 *Pushkar*

Very nice formula to get the S-curve.
However these curves do not take initial adoption (adoption at t=0) as an input and probably assumes it to be 0. How should I modify the formula so that it takes the initial adoption rate as input as well.

Thanks in advance

on 12 Jun 2007 at 3:47 pm 4 *Pushkar*

I tried the following approach for incorporating the initial adoption:

Lets say we have the following inputs:
saturation = 100%
hypergrowth = 2
takeover = 5
initial_adoption = 20%

then this can be modeled as:
saturation_new = saturation - initial_adoption
hypergrowth_new = hypergrowth
takeover_new = takeover

and the formula for each year’s penetration will be:
year_penetration_new = + initial_adoption

Essentially, I have scaled down the curve by reducing saturation level and then shifted the curve upwards to include the initial adoption rate.

Do you think this approach should work good?

on 13 Jun 2007 at 6:03 am 5 *Juan C. Mendez*

Pushkar
Thanks for your comments. Yes, your approach is exactly what is needed. Let's say you have a product that is already in the market and you'll roll out new features you expect will drive a significant increase in adoption. This initial penetration may be 5% and you expect the new features will drive to 35% in 7 time periods (months, years,…). Then you would use saturation = 30% (35-5), and add to the formula an initial_adoption parameter as you did, which will be 5%. By the way, I only used years as an example because I work in the auto industry where product lifecycles are long. The s-curve formula presented can be used with months (electronics lifecycles), days (disease spreading), or whatever time period desired

on 03 Jul 2007 at 8:22 am 6 *Molly*

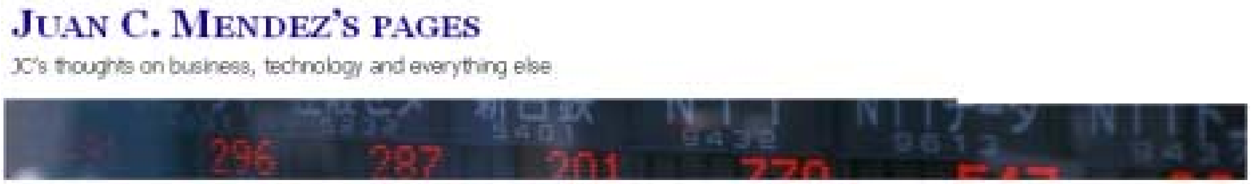
Juan - I know that you have mentioned that the 81 in the formula can be changed to represent different growth percentages in the first part of the tail. Could you tell me how that number is calculated so that I may have the option of choosing any number between 0% and 100% instead of just 10%, 20%, and 5% with 81, 16, or 360.

on 06 Jul 2007 at 9:22 pm 7*Juan C. Mendez's pages » Blog Archive » Math on the simplified market adoption s-curve for Excel*

[…] got a number of questions on the simplified Excel s-curve formula I published some time ago, so here are more details for those interested in the math behind it. The previous posting focused […]

on 06 Jul 2007 at 9:29 pm 8 *Juan C. Mendez*

Molly
Thanks for your comment. I posted a note with the math at
http://jcandkimmita.info/jc/2007/07/excel/math-on-the-simplified-market-adoption-s-curve-for-excel/
Usually I forget the math when I need to use the formula, and the trick I use is to enter the formula with the factor (81,16,360, etc) as a reference to a cell, instead of a fixed value, then use Excel's Goal Seek to change that cell until I get the desired value for the period hypergrowth. Finally, I simply replace the formula in all the cells with the computed constant.
Good luck with your modeling!



Math on the simplified market adoption s-curve for Excel

Jul 6th, 2007 by Juan C. Mendez

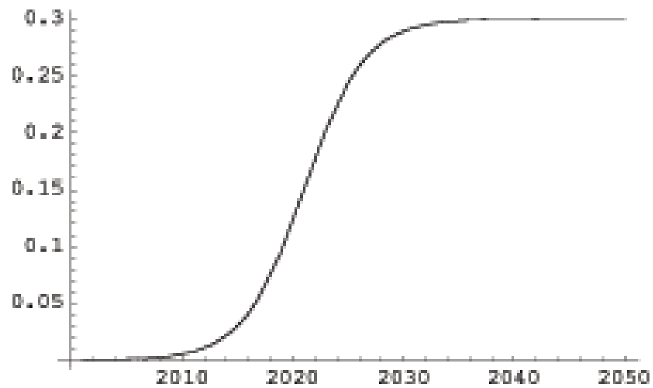
I've got a number of questions on the simplified Excel s-curve formula I published some time ago, so here are more details for those interested in the math behind it. The previous posting focused on how business analysts sometimes need to model market adoption, and provided a simple and easy to maintain formula to do so in Excel.

The formula **=saturation/(1 + 81^((hypergrowth + takeover/2 - year)/takeover))** suggested for Excel is a simplification of the formula for a sigmoid function (See the Wikipedia article http://en.wikipedia.org/wiki/Sigmoid_function)

$$P(t) = \frac{1}{1 + e^{-t}}$$

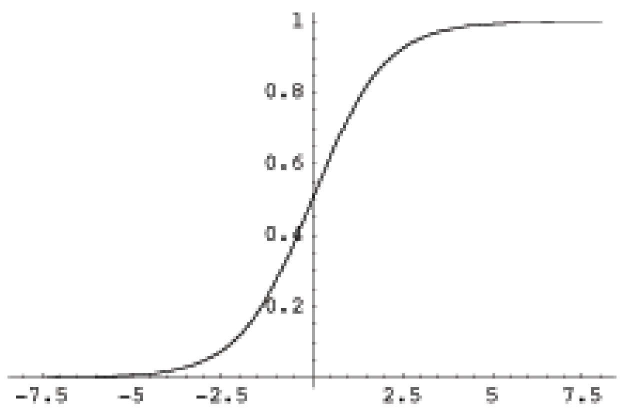
The graphic below shows the shape of both functions is identical. The **saturation** parameter just scales the function to a desired value, instead of going from 0 to 1. The factor 81 on the Excel formula determines how "sharp" the curve is, in this particular case, reaching 0.1 at the period **hypergrowth** and 0.9 at **hypergrowth + takeover**. Note that 81^x can be re-written as e^(ln(81)*x), so whatever factor is used there is simply going to affect the shape by compressing or expanding it horizontally.

```
In[19]:= saturation = 0.30;
         hypergrowth = 2015;
         takeover = 12;
         Plot[saturation / (1 + 81^((hypergrowth + takeover / 2 - year) / takeover)),
          {year, 2000, 2050}]
```




```
Out[22]= - Graphics -

In[14]:= Plot[1 / (1 + E^(-year)), {year, -8, 8}]
```

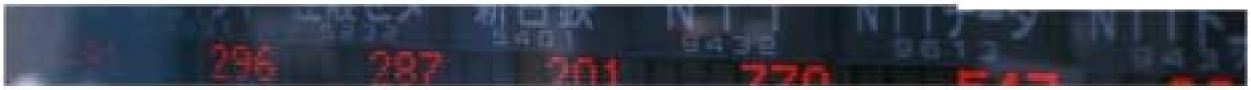



```
Out[14]= - Graphics -
```

This is how the scaling factor can be computed. Let's say we want the penetration to be 5% at the period specified by hypergrowth. We can work out the solution off the second function. We need to solve for 1/(1+e^(-x) == 0.05, which gives x=-2.94444. Since the function is symmetrical, we also know for x=2.94444 P(x) == 0.95.

Since factor^((hypergrowth + takeover/2 - year)/takeover)) can be re-written as e^(ln(factor)*(hypergrowth + takeover/2 - year)/takeover)), we can solve ln(factor)*(hypergrowth + takeover/2 - (hypergrowth + takeover))/takeover == 2.94444. Reducing all the math, we arrive to

1/(1 + e^(-0.5*ln(factor))) == 0.95, and factor would be 361. If the desired penetration at hypergrowth is 20%, then we solve 1/(1 + e^(-0.5*ln(factor))) == 0.80, leading to factor == 16



Relationship between the Bass and the logistic market adoption models

Jul 30th, 2007 by Juan C. Mendez

The simplified market adoption model I described on previous postings (1,2) is an Excel implementation of a kind of logistic function. The Bass model is one of the most popular models used in marketing, and management of technology to think about product introductions. (See Wikipedia article http://en.wikipedia.org/w/index.php?title=Bass_diffusion_model). From a mathematical perspective, when the parameter p is 0, the Bass model reduces to the logistic function.

What is most interesting, from a business perspective, is how you arrive to each of those functions by modeling real-world interactions. On both models, you can conceptualize the world as two different pools of people (or stocks, in the system dynamics terminology). One is the pool of potential adopters, and the other is the pool of adopters. The flow between these two pools is controlled by the adoption rate, a variable that models how probable is that a potential adopter becomes “infected” by a current adopter. On the logistic model, it depends solely on how much they interact, how big the total population is, and how “contagious” the product is. On the Bass model, an additional parameter accounts for external factors, the most common being advertising. The Bass model overcomes what is called the startup problem of the logistic model: how a initial base of zero adopters can spread “infection” of the product.

There are more refinements that can be done to the Bass model: accounting for changes in the total population over time, learning and experience curves, etc. For projects where the sensitivity of the model to these factors is high, I definitely recommend to spend more time calibrating your model, understanding which of the different available curves fits better any data you may have, and most critical of all, whether the chosen coefficients for any of the functions have strong impacts on the critical business issues you want to model — capacity planning, pricing, profitability, etc.

For many projects like business plans, revenue projections, etc. I’m willing to sacrifice the ability to fine tune parameters in a model like the BDM for the clarity provided by a model like the Excel logistic function I described. I can generate more tangible conversations with executives by discussing what they believe will be the takeover time, when they believe it will be the start of the fast growth, how much share they believe will be reached in steady state, etc.