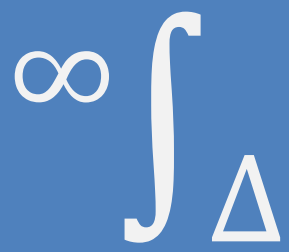

Understanding the Future

Daniel Research Group

The Logic of Growth and the Limits to Growth

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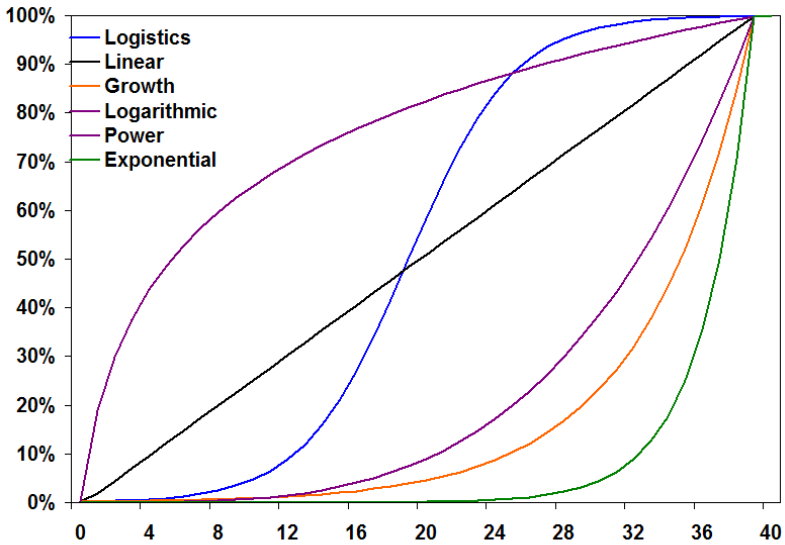
The Logic of Growth and the Limits to Growth

Stephen J. Daniel is founder and president of **Daniel Research Group,** a technology market research firm specializing in the design, development and application of market models and forecast. The following article contains material drawn from his book, *Understanding the Future, A Practical Guide to Designing and Developing Context Specific Segmented Forecasts and Models For Technology Markets*

Scientists, economists, sociologists, and entrepreneurs have observed, studied, and theorized about the nature of growth and it limits for over 300 years. While growth and its termination can take many forms, the "S" shaped curve appears frequently. *"Why this shape and not some other*?", needs to be understood by the Model Builder, and specifically how these curves may or may not describe technology markets.

Growth Curves



The graph above shows many common curves that all describe growth over time. It is clear that they all take different paths to get from start to finish. What causes the difference? First, it must be recognized that observed growth patterns are the result of two processes; (1) a

process that drives the growth, and (2) a process or factor that slows and/or terminates it. Second, regardless of the domain, there are common fundamental elements of the systems being observed.

- ✓ **Population** - A population of individual entities exists that can change some internal attribute. The entities may be a biological cell, a member of a social group, or a customer.

- ✓ **Communication Process** - One or more communication methods must exist that transmit information to the individual entities. This may be a virus or bacteria, hearing or reading a political statements, or noticing that your friend has a new cell phone application.

- ✓ **Change Process -** The process that causes the individual entity to change triggered by the reception of information. This may be the absorption of some biological agent, considering a political point of view, or thinking about purchasing a new cell phone application. While receipt of the information triggers the change process this does not imply that a change will actually occur.

Furthermore, the communication process may take two different forms.

- ✓ **External** – information is transmitted to all of the individual entities simultaneously at a single instant, or continuously over time. This may be the application of heat to a collection of cells, or a political TV ad, or an email campaign.

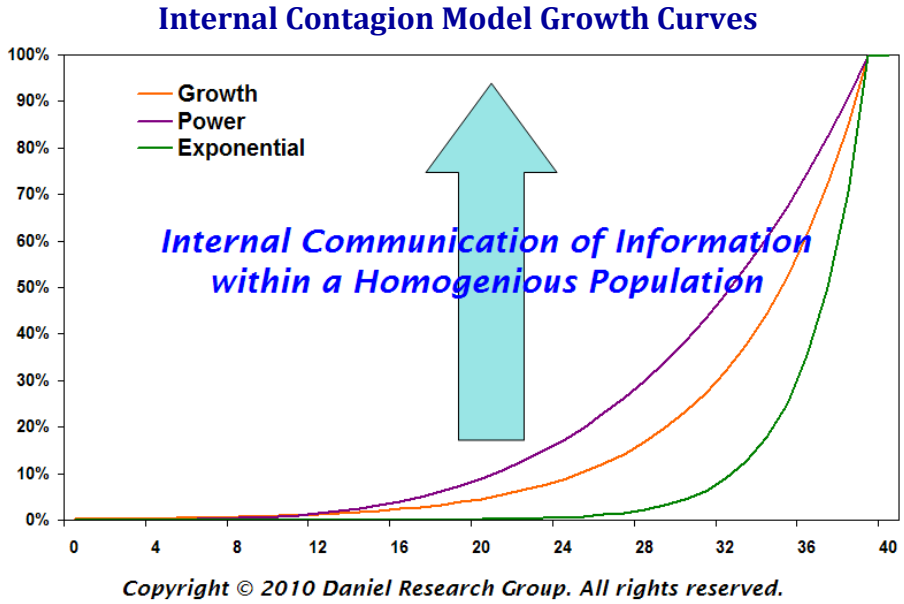
- ✓ **Internal** – Information is passed on from individual entity to another by direct contact. This may be by physical contact between cells, conversation among friends, or observation of others.

Finally, the population may or may not be uniform in term of the susceptibility to change as a result of receiving the information. The population may be considered:

- ✓ **Homogeneous** – if all units will react the same way upon receipt of the information.
- ✓ **Heterogeneous** – if there are differences among the units in their susceptibility to change as a result of receiving the information. The causes for this difference may be complex and involve many attribute of the individual entities.

The communication type coupled with the nature of the population may be used to create a process classification taxonomy suitable for selecting the best functional form for modeling purposes. In the four classifications below the all of the individuals in the population start in an unchanged state. In a biological model, this would be defined as un-infected. In a social model, this would be defined as not adhering to a specific belief, or exhibiting a specific behavior. In a market model, this would be defined as not yet having adopted the innovation, i.e. buying the product.

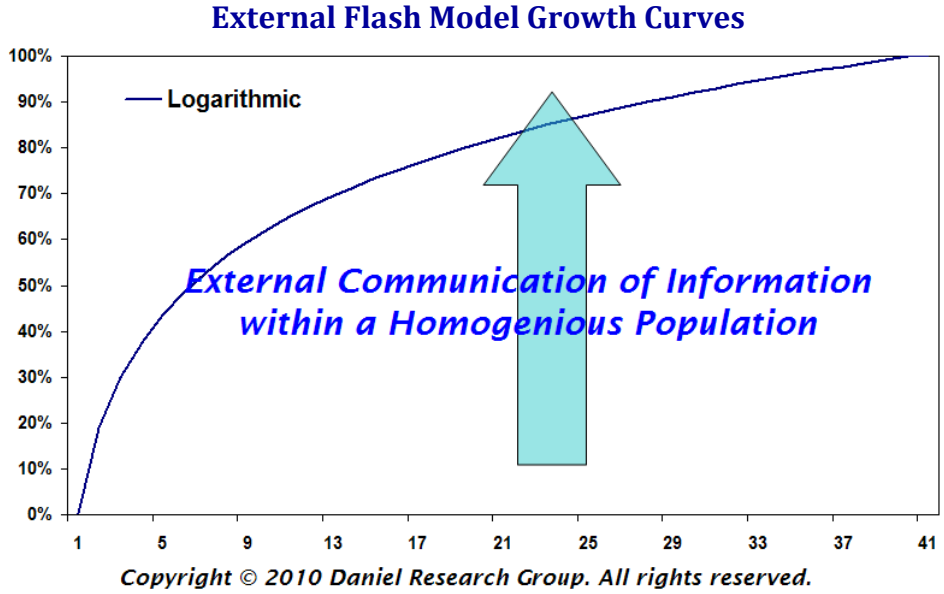
Contagion Models: (Homogeneous Population with Internal Communication)



A single or small group of individuals change state (becomes infected, changes belief or behavior, or buys the product) and then sends out information that will trigger this same change in others by communication with all other individuals that it is in contact with. When an unchanged individual receives the information it's too changes and then communicates with its neighbors. The process continues until all of the individuals in the population have received the information and have changed, at which time the process abruptly terminates because there are no unchanged individuals left. Because the population is homogeneous in terms of reaction to the receipt of information, they will all change simply upon receipt of the information.

The growth process is driven by the rate at which the information propagates throughout the population. This is primarily determined by the nature of the information connectivity within the population. The process abruptly stops when 100% of the individual have been changed. Exponential, compound growth (CAGR) and power curves that exhibit accelerating growth best describe this classification. As a total life cycle model, this is rarely observed in technology markets because of the assumption of homogeneity. However, within a bounded market segment, i.e. homogeneous with regard to the adoption decision attributes, this pattern of viral growth will be observed.

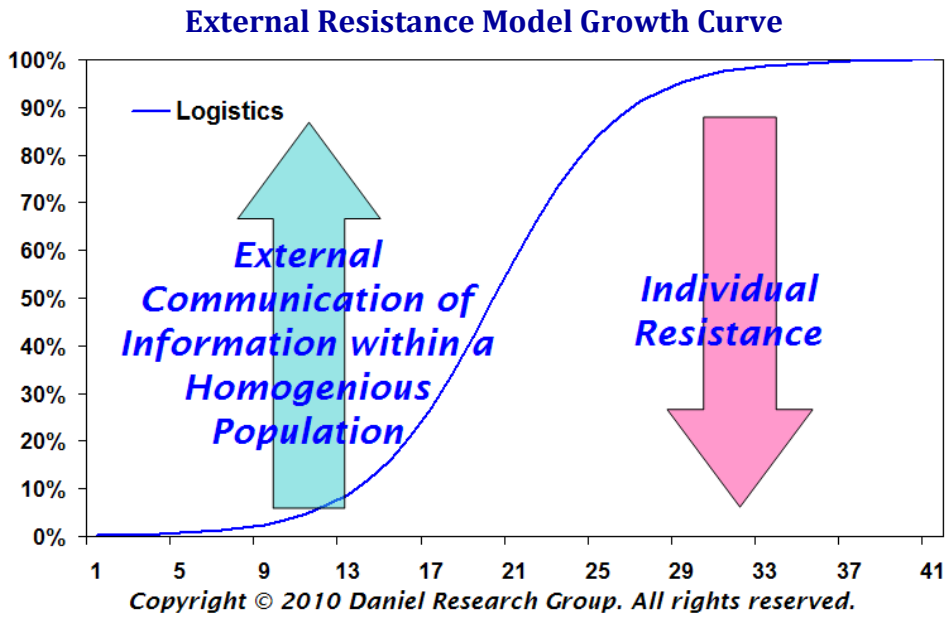
Flash Models (Homogeneous Population with External Communication)



All of the individuals in the population receive the information from an external source simultaneously, at a single point in time. Once an individual receive the information it changes. Theoretically, since all of the individuals receive the information at the same time, and they all will react the same way, then all the individuals should change instantly and simultaneously. In practices, this is rarely the case since it may take some period of time for the information to be received by all of the individuals, i.e. there is some latency in the communication system. The growth process is driven by the rate at which the information is received by the population and terminates when there are no unchanged individuals left.

Flash models will exhibit decelerating growth with the largest percent of the population undergoing change in the initial period. The logarithmic curve will best fit the observed data from this classification. Versions of this model has been used to explain consumer purchasing behavior for many non-durable goods. In the extreme, this model describes panic buying behavior.

Resistance Models (Heterogeneous Population with External communication)

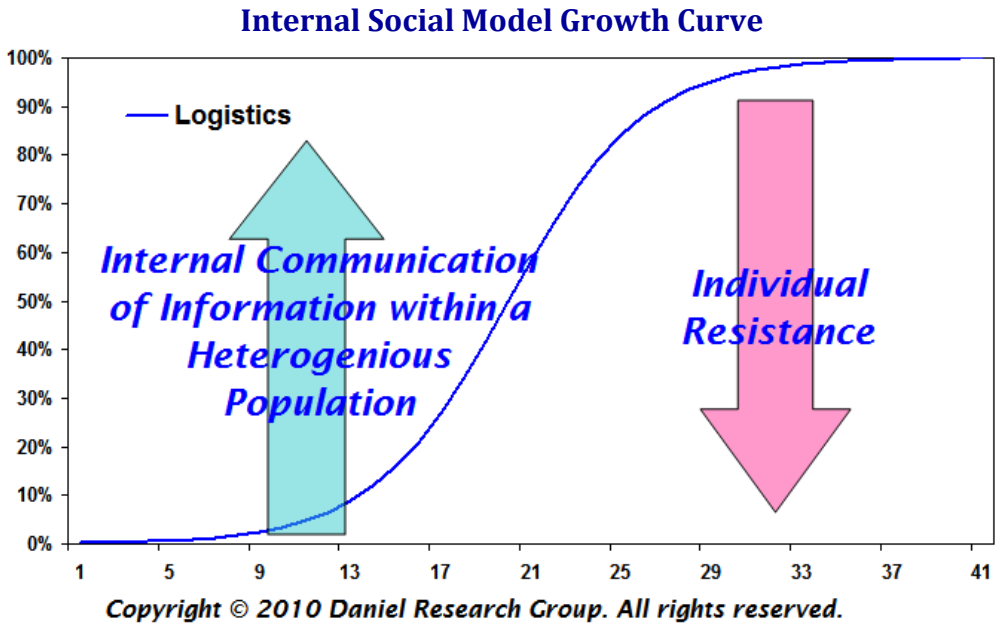


The individuals in the population receive the information from an external source simultaneously at a single point in time, or over a period of time. However, the individuals differ as to the susceptibility to change. Some change instantly while others delay the change, and still other do not ever change, sometimes terminating the process before 100% penetration. The change process is therefore dependent on these additional attributes that vary across the population and govern the susceptibility to change. Both the growth process and the termination process are dependent on the distribution of the resistance attributes in the population. The observed data from this classification will best fit a logistics curve since the individuals' attributes will act as resistance to change and therefore slow the growth process.

A clear example of this is the way kernels of corn pop as heat is applied. If all the corn kernels were physically identical, they would all pop simultaneously. However, the kernels are not physically identical, they differ in size and starch content. Since these differ over the population, the rate at which the kernels pop will vary over time. It is important to note that whether or not a kernel pops is totally independent of what any other kernel does. The percentage of kernels that have popped over time will create an "S" shaped logistic curve that is entirely caused by the heterogeneity of the kernels in terms of starch content.

An external marketing message may be considered analogous to the heat and the kernels analogous to potential customers. If the chance that a customer buys the product is dependent on some decision influencing factor, and that factor is distributed heterogeneously throughout the population, then that factor will act as a resistance force to the growth process and produce an "S" shaped logistics curve

Social Models (Heterogeneous Populations and Internal Communications)



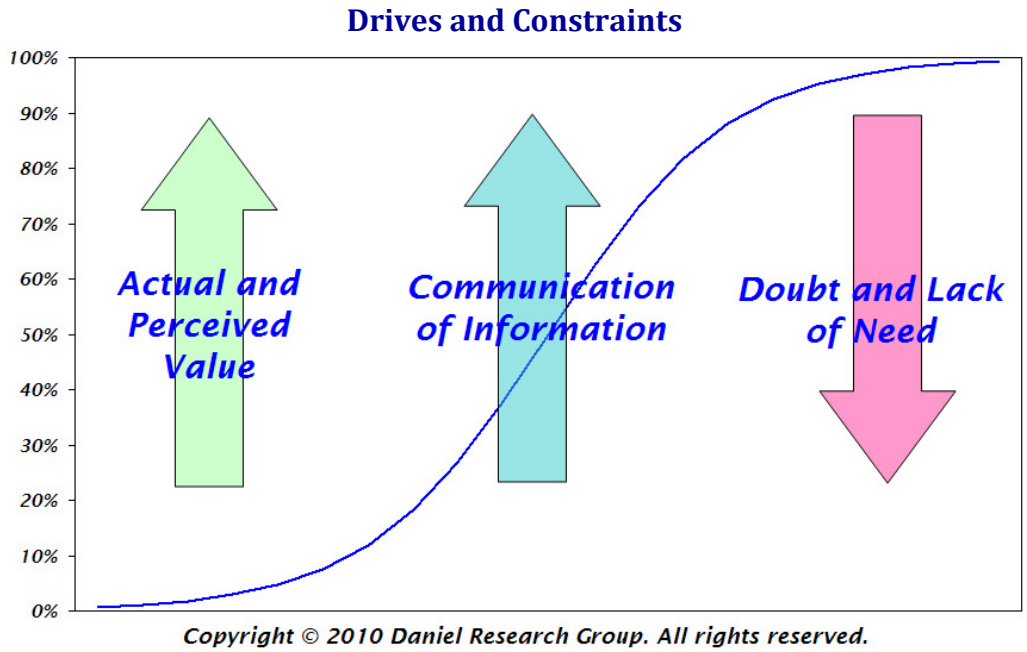
A single or small group of individuals changes and then communicates information to its neighbors that may trigger their change. However, the susceptibility to change in each unit varies across the population therefore only some of the units that receive the information will change. This is identical to the resistance model. The only difference is that information is communicated internally from individual to individual rather than from an external source.

While the growth process is driven by the rate at which the information propagates through the populations it is increasingly countered by the resistance factor in the remain unchanged portion of the population. In some case, growth may even stop prior to reaching 100% of the population. The observed data from this classification will best fit a logistics curve.

From the above classification examples, it should be clear that if the population is homogeneous then the penetration rate, i.e. the rate of adoption, is simply the information propagation rate. If the communication process is internal than the process will be best modeled with exponential, growth, or power functions. If the communication process is external then a power or logarithmic function will provide the best model.

However, if the population is heterogeneous then regardless of the communication process penetration will follow a logistics curve**.** As time progresses the remaining unchanged population will contain an increasing proportion of individuals that are less likely to change. This implies that in heterogeneous populations factors are present that exert a counter force, a resistance to the process driving change, and that these also increases in strength over time. It is the heterogeneity in the population that creates the counter force to the communications driven growth process, and therefore the "S" shaped logistics pattern.

There may also be additional factors in some systems that drive the growth. In these systems, the strength of the information being communicated will increase as a function of the number of units that have changed. In technology market terms, the perceive and actual value of a product often increases as the number of buyers and users increase.



Summarizing, as time progresses the communication of information about a product to more and more potential customers drives growth. A second forces driving growth is the actual and perceived value of the product that is dependent on the increasing number of customers and users (network externalities). Countering those forces is the increasing portion of the remaining population that has no real or perceived need for the product, or requires an increasing amount of convincing to overcome doubt.

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Daniel Research Group offers consulting and market research services to clients whose products and services are technology based or enabled. The primary focus is on providing results, solutions, consulting and training to clients that have strategic and tactical decisions that require Forecast, Segmentation, Market Share, and other market modeling requirements These engagements are supported with the full range of traditional market research data gathering and analysis services, including quantitative and qualitative surveys, focus groups, demographic and firmographic data acquisition and analysis, as well as input from technology and industry experts. While our emphasis is on delivering data and actionable recommendations, we often design and develop custom models and modeling tools for client use as well as providing training in these areas.

Stephen J. Daniel - President

Mr. Daniel's three decades in the Information Technology Industry has given him a unique blend of Market and Technology experience coupled with a deep understanding of Market Research Methodology. His primary strength is in understanding the decision making context within which the results of his research will be applied. This is manifested by his ability to design and execute studies that precisely meet client objectives on schedule at reasonable costs.

After receiving his BS in Finance in 1970 from Northeastern University, Mr. Daniel earned an MBA in Quantitative Analysis from New York University in 1974. He is a member of the American Statistical Association, The Market Research Association of America, the American Marketing Association and the Qualitative Research Association of America.

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