GLOBAL FINANCIAL STRATEGIES
www.credit-suisse.com

Total Addressable Market

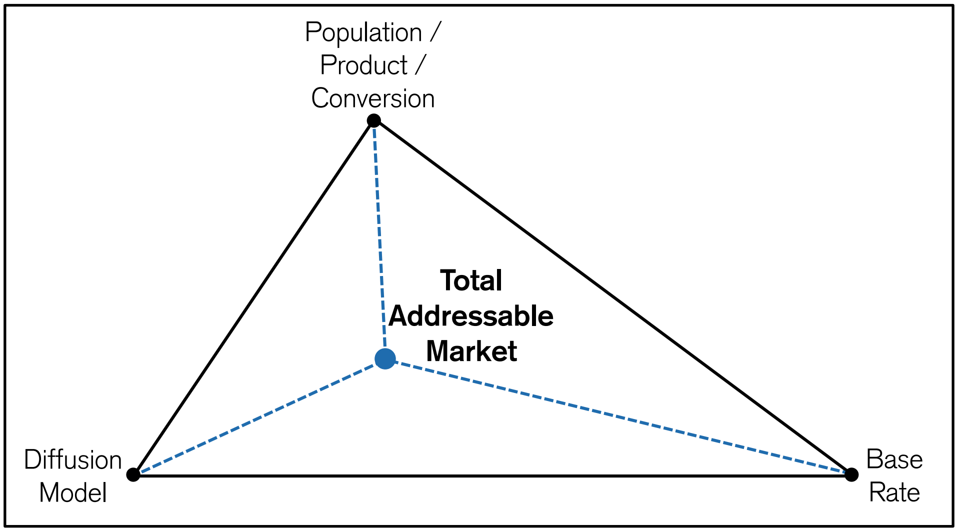
Methods to Estimate a Company's Potential Sales

September 1, 2015

Authors

Michael J. Mauboussin
michael.mauboussin@credit-suisse.com

Dan Callahan, CFA
daniel.callahan@credit-suisse.com



- The ability to calibrate the total addressable market (TAM) is a major part of anticipating value creation. Assessing value creation requires understanding how much a company can invest and the returns those investments will earn.
- We define TAM as the revenue a company could realize if it had 100 percent share of a market it could serve while creating shareholder value.
- This report provides a framework for estimating TAM through the process of triangulation using three methods. The first is based on population, product, and conversion. Next we examine a diffusion model, which not only addresses the absolute size of the market but also the rate of adoption. Finally, we discuss the usefulness of appealing to base rates as a reality check for optimistic estimates of TAM and growth rates.
- Companies can expand their TAMs through business category evolution, hence placing their products or services at the heart of an ecosystem. Done successfully, this allows the company to take advantage of network effects, encourages customers to remain within the ecosystem, and extends a company's period of competitive advantage.
- We include a checklist to guide analysis and discussion.

Table of Contents

Executive Summary

- The ability to calibrate the total addressable market (TAM) is a major part of anticipating value creation. Since 1960, about one-third of the value of the S&P 500 Index has been attributable to the anticipated payoff from future investment. Assessing value creation requires understanding how much a company can invest and the returns those investments will earn.

- We define TAM as the revenue a company could realize if it had 100 percent share of a market it could serve while creating shareholder value. You should recognize up front that TAM is not about how large a firm can grow to be but rather how much it can expand while adding value.

- This report provides a framework for estimating TAM through the process of triangulation using three methods. The first is based on population, product, and conversion. Next we examine a diffusion model, which not only addresses the absolute size of the market but also the rate of adoption. Finally, we discuss the usefulness of appealing to base rates as a reality check for optimistic estimates of TAM and growth rates.

- Estimating TAM is trickiest when both the market and the technology are new.

- The first approach to assess TAM is to estimate the absolute size of the market, which has three parts: estimates of the broad population, the percentage likely to use the good or service, and the revenue potential. An in-depth analysis of the absolute size of the market also requires careful consideration of factors that shape demand and supply.

- The workhorse for forecasting the rate of adoption for new products and services is a model developed in the 1960s by a marketing professor named Frank Bass. The Bass model allows for a prediction of the purchasers in a period, say for each year, as well as a total number of purchasers. The model helps calibrate TAM as well as the rate of growth in getting to TAM.

- The Bass model relies on three parameters: the coefficient of innovation (p), the coefficient of imitation (q), and an estimate of the number of eventual adopters (m). The primary way to estimate parameters is to use analogies from the diffusion of similar products or services.

- In cases where network effects are strong, it is common for one network to become dominant. For most consumer products, the market share of the leading company rarely tops 40 percent, but in businesses with strong network effects, market shares are generally well above 50 percent and commonly closer to 90 percent.

- Base rate analysis refers you to what happened to other companies when they were in a situation similar to the one you are examining. No reference class is perfect but the base rate of performance can lend a vital point of view of the plausibility of a TAM estimate. Indeed, research shows that using base rates generally improves the accuracy of forecasts.

- Companies can expand their TAMs through business category evolution, hence placing their products or services at the heart of an ecosystem. Done successfully, this allows the company to take advantage of network effects, encourages customers to remain within the ecosystem, and extends a company's period of competitive advantage.

Introduction

The ability to calibrate the total addressable market (TAM) is a major part of anticipating value creation. Since 1960, about one-third of the value of the S&P 500 Index has been attributable to the anticipated payoff from future investment. Assessing value creation requires understanding how much a company can invest and the returns those investments will earn.[1]

We define TAM as the revenue a company would realize if it had 100 percent share of a market it could serve while creating shareholder value. TAM is a concept that executives and investors use frequently, but that few define properly or thoughtfully. You should recognize up front that TAM is not about how large a firm can grow to be but rather how much it can expand while adding value.

An exchange in 2014 between Aswath Damodaran and Bill Gurley over the prospects for Uber, the transportation company, brings TAM into sharp focus. Damodaran, a professor of finance at the Stern School of Business at New York University and a recognized expert in valuation, suggested the company was worth about $6 billion, a fraction of the $17 billion value implied by a round of financing the company had completed at that time.[2] (A round in the summer of 2015 valued the business in excess of $50 billion.[3])

Gurley, a highly successful venture capitalist with Benchmark Capital and an early investor in Uber, responded with an article called "How to Miss By a Mile: An Alternative Look at Uber's Potential Market Size," in which he argued that Damodaran's valuation grossly underestimated the magnitude of Uber's potential TAM.[4] Both men are believers in using discounted cash flow to value the business so the crux of their disagreement, which was refreshingly civil, sat squarely on the perceived size of Uber's opportunities.

Damodaran calculates Uber's TAM based on the taxi and car service business, which he estimates to be $100 billion. He then assumes the company can reach a market share of 10 percent, and proceeds to calculate the value of the business. Gurley suggests that Uber's TAM is in the range of $450 billion to $1.3 trillion, and argues the company can capture a market share of up to 25 percent. Gurley comes to a wildly different conclusion about value because the high end of his estimate for addressable TAM is more than 25 times larger than what Damodaran assumes. To buttress his case, Gurley notes that Uber's revenue in San Francisco, one of its early markets, is already "multiples bigger" than the $140 million of total revenue from the taxi and car service industry. And business is still growing rapidly in that region.

After a brief discussion of product categorization, this report provides a framework for estimating TAM through the process of triangulation. We use three methods. The first approach is based on population, product, and conversion. Next, we examine a diffusion model, which not only addresses the absolute size of the market but also the rate of adoption. The key is to come up with sensible parameters to inform the model. Finally, we discuss the usefulness of appealing to base rates as a reality check for optimistic TAM estimates and growth rates.

In the last section of the report we discuss TAM in the context of business category evolution. Increasingly, companies seek to build ecosystems around their goods or services that can expand their addressable market. This is relevant in understanding the popular topic of the "internet of things," where people or objects are nodes of an interactive network and information is freely transferred between the nodes.

Categorizing New Products

The categorization of products is a logical starting point in assessing market size.[5] There are several categories of products, but we can arrange them based on whether the product technology and customers are new or current (see Exhibit 1). This allows us to appraise a company's strategy to promote the product and provides guidance about which forecasting method is likely to be most effective.

For current technologies with current customers, captured in the bottom left corner of exhibit 1, the basic analysis boils down to how much the market will grow and how market shares will change. These are not new products, so a TAM analysis is of limited use. Companies can influence their TAM through pricing strategy and product enhancement.

Exhibit 1: Classification of New Products

		Current Technology	New Technology
New Customers	Product Strategy	Market Development	Diversification / Disruptive
	Forecast Method	Customer and Market Analysis	Scenario Analysis (What If)
Current Customers	Product Strategy	Market Penetration	Product Development
	Forecast Method	Sales Analysis	Product Line / Life Cycle Analysis

Source: Kenneth B. Kahn, New Product Forecasting: An Applied Approach *(Armonk, NY: M.E. Sharpe, 2006), 9.*

On April 2, 1993, Philip Morris cut the price of Marlboro cigarettes by 20 percent in an effort to prop up its market share. This is an example of a pricing strategy. The stock market didn't like the decision to trade higher market share for lower profits, and the shares of Philip Morris stock lost almost a quarter of their value. Product enhancement can reflect improvement in the product itself or in elements of design or packaging. Think of the evolution of packaging for Heinz ketchup.

There is a positive correlation between market share and profitability, which encourages some executives to focus on market share goals. However, evidence from academic research shows that corporate objectives focused on competitors, including targets for market share, are generally harmful to profitability.[6]

Current technologies that have applications for new customers (upper left corner of exhibit 1) and new technologies used by current customers (bottom right corner) are the categories where a TAM analysis is most relevant. Current technologies for new customers include geographic extension and novel applications of existing products. The classic example of the latter is the use of Arm & Hammer baking soda as a means to manage odor in a refrigerator. Pharmaceutical products with therapeutic applications beyond their initial target are another case in point.

New technologies for current customers fall in a range from the prosaic, such as line extensions, to disruptive innovations. An instance of a line extension is the launch of Colgate Total toothpaste, which included novel antibacterial technology, in 1997. That product quickly gained one-tenth of the U.S. toothpaste market.

The theory of disruptive innovation was formalized by Clayton Christensen, a professor at Harvard Business School. Part of the theory describes the process by which products enter a market using a new “value network,” essentially a different business model. The introduction of electronic books and the interplay between Amazon.com’s e-book inventory and the Kindle, its reading device, is an example of an innovation that disrupted the book industry.

Estimating TAM is trickiest when both the technology and the customers are new. Here, the number of ultimate adopters, as well as the rate of adoption, is unknown. This is where forecasters have made some of the most embarrassing blunders of all time. The market for computers? Maybe five, said the head of IBM in the early 1940s. How about personal computers? “There is no reason anyone would want a computer in their home,” said the founder of Digital Equipment Corporation, a maker of minicomputers.[7]

The value in categorizing new products is to get a sense of the best way to forecast the TAM. In some cases the process is as straightforward as counting potential users and estimating market share and pricing. In other cases, especially in those dealing with novel goods or services where network effects are relevant, the range of outcomes is much wider and less certain. Let’s take a look at some specific ways to estimate TAM.

Market Size: Population, Product, and Conversion

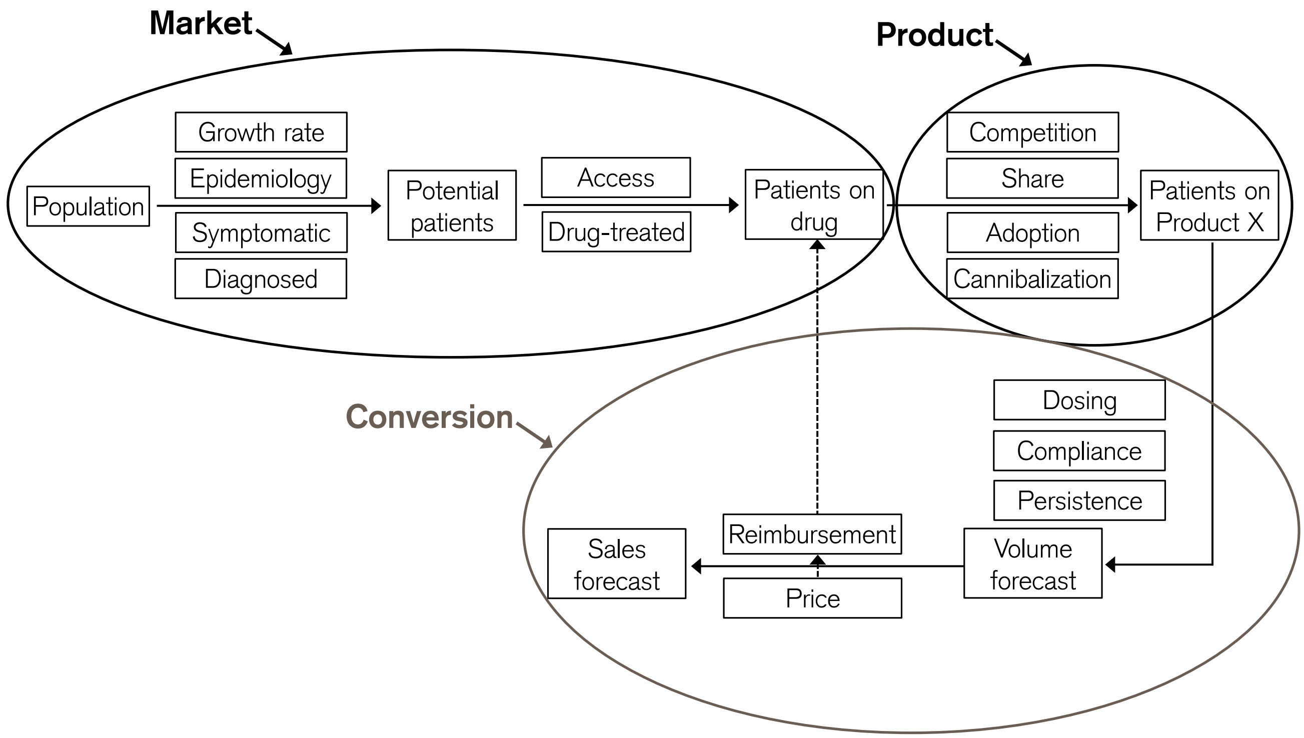
The first approach to assess TAM is to estimate the absolute size of the market, which is simply the number of potential customers times the expected revenue per customer. This model is popular for estimating the sales potential for a new drug.[8] Exhibit 2 shows the components of the TAM estimate. There are three parts to this analysis: estimates of the broad population, the population likely to use the good or service, and the revenue potential. Here’s an examination using statins, cholesterol-reducing drugs, as a case study.

- **Population.** The analysis begins with the population of individuals who may have a particular disease. Those patients must consult with a health care provider, be properly diagnosed, and seek treatment. More than 20 percent of the 320 million people in the United States have high cholesterol. A joint study by the American College of Cardiology and the American Heart Association suggests that 56 million Americans between the ages of 40 and 75, roughly three-quarters of those with high cholesterol, are eligible to consider a statin. About 25 million Americans are currently taking statins.[9]

- **Product.** There are about a half-dozen prescription statins available in the U.S. They vary in efficacy. Factors that determine market share include the characteristics of the drug itself, marketing, pricing, and patent protection. For other pharmaceutical products, additional factors in determining the rate and likelihood of adoption include method of delivery, frequency of use, and dosage.

- **Conversion.** Just because a patient is prescribed a drug doesn’t mean that he or she will take it as suggested. Compliance is a large issue. For example, studies suggest that about half of the patients who receive a prescription for a drug to lower lipids stop taking it within six months. Only 40 percent still take the drug after a year, and roughly one-quarter after five years.[10] The main reasons patients are non-compliant is that they don’t know they are supposed to refill their prescription and they don’t like the side effects. After you come up with a forecast for volume, you can consider the price for the product. This ultimately allows for an estimate of the sales for the product.

Exhibit 2: Components of Total Addressable Market Forecast



Source: Based on Arthur G. Cook, Forecasting for the Pharmaceutical Industry: Models for New Product and In-Market Forecasting and How to Use Them *(Burlington, VT: Gower Publishing Company, 2006), 36.*

Researchers at McKinsey & Company, a consulting firm, studied the sales forecasts for new drugs made by analysts at brokerage firms.[11] The data included more than 1,700 individual forecasts on 260 drugs over a recent ten-year span. The researchers found that the median error of all analysts for a drug's peak sales was only four percent. But the average error was large. Almost two-thirds of the estimates missed the peak revenue amount by 40 percent or more. Further, forecasts for follow-on drugs were no better than the first launches within a therapeutic class.

A more in-depth analysis of the absolute size of the market requires careful consideration of factors that shape demand and supply. We'll start with demand.

From the outset, it is useful to distinguish between the user and the payer. They may not be the same. For example, parents buy goods and services for their young children, and pet owners purchase on behalf of their pets.[12] This point is especially relevant in health care, where the consumers and payers are separate. In these cases, you need to consider the needs of the user as well as the incentives of the payer.

Other factors to consider in assessing demand include:

- **Financial resources.** How much money do the buyers have? Are their resources growing or shrinking?

- **Physical limitations.** This includes a consideration of how much a person can eat, drink, wear, or use a product. A market becomes saturated when most people are using as much of the product as they can. For instance, shifts in how consumers allocate their time are having a profound effect on the media and advertising industries, and the dust has yet to settle.

- **Elasticity of demand.** Elasticity measures the change in demand as a function of a change in price. Inelastic goods show little decrease in demand as prices increase, whereas demand drops more rapidly for elastic goods. So as prices rise, TAM may grow for an inelastic good and shrink for an elastic good.

- **Cyclicality.** Some products have cyclical demand, which cautions against extrapolating short periods of results into estimates of TAM.

- **Substitution and substitution threats.** Substitution is a big deal in assessing TAM. How does a consumer allocate his or her time and money today and how might that change over time? This factor appears at the center of the disagreement between Damodaran and Gurley on Uber: Damodaran considers only that Uber will be a substitute for taxis and limos, whereas Gurley assumes that it will be a substitute for the ways we move people and things from point A to point B.

Value creation is at the center of a careful definition of TAM. The question is not how big the company can get, but rather the revenue potential assuming the company can generate a return on investment excess of the cost of capital.[13] This is relevant as we consider TAM from the supply side.

Similar to the case with users and buyers, we must recognize that suppliers may be different than sellers. For example, most automakers use a network of dealers to sell their cars. So, the TAM for the automakers reflects, at least to some degree, the location and quality of their dealer network.

Other factors to consider in assessing supply include:

- **Ability to supply.** Considerations include a business's production capacity, the infrastructure to get goods to market, and its geographical footprint. A company's ability to supply a good or service is commonly limited to a fraction of the market it can theoretically access.

- **Unit growth and pricing.** You want to consider carefully where the industry is in its life cycle and what that implies about the rate of growth and pricing flexibility. Assess how well capacity, whether based on manufacturing, service, or knowledge production, matches the rate of demand growth. Ask whether the company uses pricing as a lever to drive scale or to increase profitability. As we will see, this is relevant for businesses seeking to capture network effects.

- **Regulatory constraints.** Regulations can play a large role in shaping TAM. Economic regulation creates rules that limit which companies can participate in an industry. These include capital requirements, tariffs and quotas, price or rate of return caps, and licenses. Social regulation attempts to address potential market failures. Emission standards and mandated information disclosure are examples. Changes in regulation can shrink or expand TAM.

- **Incentives.** This discussion can start with the classic principal-agent problem, where management may make choices that increase their utility at the expense of shareholders. For example, companies in the U.S. are investing in their businesses at a very measured rate. Shareholders may want to see the companies invest more aggressively, and some have said as much publicly.[14] Ironically, the increase in compensation in the form of restricted stock units, meant to make the interests of executives more aligned with those of shareholders, may be encouraging risk aversion. Conflicts can also happen within the business. For example, a traditional brick and mortar retailer may fear too much success with an online offering as the customer migration may harm the economics of the physical stores.

- **Scale.** Economies of scale are often crucial for sustainable competitive advantage. But most companies can only achieve scale advantages on a local basis. Few can do it nationally or internationally.[15] Since creating value is in the definition of TAM, addressable TAM is commonly smaller than total TAM because of the difficulty of gaining scale.

- **Niches.** If two or more competitors are in the same market, they often concentrate on different segments so as to reduce competitive conflict. As a consequence, the TAM is not as large as it appears.

Estimating the absolute size of the market by considering population, product, and conversion is a solid foundation for assessing TAM and will likely remain so. However, we can add richness to our analysis by considering a social dimension.

TAM and the Bass Model

The workhorse for forecasting the rate of adoption for new products and services is a model developed in the 1960s by a marketing professor named Frank Bass.[16] Bass was influenced by Everett Rogers, a professor of communications and sociology, who wrote the seminal book, *Diffusion of Innovations*.[17] The Bass model allows for a prediction of the purchasers in a period, say for each year, as well as a total number of purchasers. So the model helps calibrate TAM as well as the rate of growth in getting to TAM. This rate of growth is essential to valuing a business.

A simple version of the Bass model relies on three parameters:[18]

- **The coefficient of innovation (p).** This captures mass-market influence. The parameter p is at play if you are excited about buying a good or service even though you don't know anyone who has it yet, or if advertising has influenced you.

- **The coefficient of imitation (q).** This reflects interpersonal influence. It's basically the power of word of mouth or social contagion. You want something because all of your friends have it.

- **An estimate of the number of eventual adopters (m).** A parameter that determines the size of the market.

The key to a model's usefulness is coming up with thoughtful inputs for the parameters. We'll discuss how to do that in a moment.

Say we want to determine the number of adopters (N) during a specific period. The equation for the Bass model is as follows:

$$N(t) - N(t-1) = [p + qN(t-1)/m] \times [m - N(t-1)]$$

The equation looks intimidating, but we can break it into parts to make it a lot easier to grasp. It basically says that new adopters equal the adoption rate times the number of potential new adopters.

$N(t) - N(t-1)$, the number of adopters during a period, is simply the difference between the users now, $N(t)$, and the users in the prior period, $N(t-1)$. So if there were 110 users at the end of period t and 100 at $t-1$, there would have been 10 adopters during the period (110 – 100 = 10).

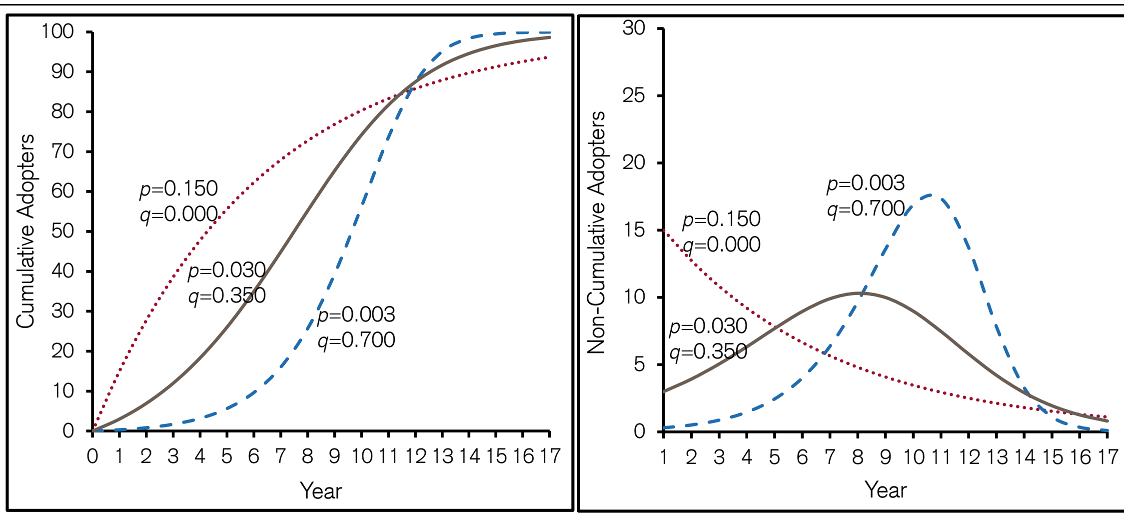
The first term on the right side of the equation, [$p + qN(t-1)/m$], spells out the rate of adoption. People are more likely to adopt a product or service if lots of other people are already using it. So the coefficient of imitation, q, is applied to the proportion of users, which is $N(t-1)/m$. Let's say the number of eventual users is 500. That means that if $N(t-1)$ equals 100 and m equals 500, then $N(t-1)/m$ is 0.20 (100/500 = 0.20). You multiply q by that penetration rate. The coefficient of innovation, p, is independent of the number of users.

The second term on the right side is the number of users who have not yet adopted the product. It's the total number of eventual adopters, m, minus the number of adopters in period $t-1$. With an m of 500 and $t-1$ of 100, we know the number of people who have yet to adopt the product is 400 (500 – 100 = 400).

One study of diffusion found that the average coefficient of innovation, p, was 0.037, significantly smaller than the average coefficient of imitation, q, of 0.327. Appendix A shows the empirical parameters for more than 50 products.[19]

Exhibit 3 shows the output of the model assuming an m of 100, and a range of values for p (from 0.003 to 0.150) and q (from 0.000 to 0.700). In cases when q is larger than p, the penetration of users follows an S-curve, as the left side of the exhibit shows. Thus, when the coefficient of imitation is greater than zero, the proportion of users that adopt follows a pattern similar to a normal distribution. You can see this on the right side of the exhibit. This is very consistent with the work of Everett Rogers.[20]

Exhibit 3: Output from the Bass Model



Source: Credit Suisse.

Investor application of the Bass model. Investors can use the model in a couple of ways. The first is to estimate product potential based on the parameters from historical diffusions. Bass's model of the adoption of satellite television is an example of this approach.[21]

In 1992, Bass forecasted the number of satellite television subscribers for 1999 based on market research, past diffusion patterns, and management guidance. In the model he assumed that m, the number of eventual adopters, was 16 percent of homes with television sets and that the coefficients for p and q were similar to those for cable television in the 1980s. The result was a prediction of 9.4 million adopters in 1999. The actual number was just under 10.0 million (see Exhibit 4).

Exhibit 4: Bass Model Forecast for Satellite Television

	1992 forecast of homes acquiring satellite TV	Actual number of homes acquiring satellite TV	1992 forecast of penetration (%)	Actual yearly penetration (%)
1995	0.875	1.150	0.92	1.21
1996	2.269	3.076	2.37	3.21
1997	4.275	5.076	4.42	5.25
1998	6.775	7.358	6.95	7.55
1999	9.391	9.989	9.55	10.16

Source: Frank M. Bass, Kent Gordon, Teresa L. Ferguson, and Mary Lou Githens, "DIRECTV: Forecasting Diffusion of a New Technology Prior to Product Launch," Interfaces, *Vol. 31, No. 3, May-June 2001, S90.*

A second way to use the model is to start with a company's stock price and work backward. This allows for an assessment of what the market anticipates for the rate of growth in adopters as well as the total number of adopters. You can then compare the parameters imputed from the market price with empirical results to judge the likelihood of achieving those levels. This expectations approach trades the need for specificity for a general sense of plausibility.

The Bass model has another nice feature: it allows you to solve for the size of peak sales.[22] An estimate for this outcome can be very relevant for gauging expectations. You can calculate the size of peak sales with this equation:

$$\text{Size of peak sales} = m\left[\frac{(p+q)^2}{4q}\right]$$

This measure is relevant because companies and investors are tempted to extrapolate the growth rates they see in the steepest part of the S-curve, and hence anticipate too much growth. For instance, color televisions were launched in the 1950s and reached peak sales in 1968 (color televisions didn't outsell black and white models until the early 1970s). As the industry was growing rapidly in the 1960s, manufacturers extrapolated that growth and added capacity accordingly. The result was manufacturing capacity in 1968 of 14 million units, while sales topped out at 6 million.

Researchers have added a number of refinements to the Bass model in an effort to address the model's limitations.[23] But since its introduction 45 years ago, the basic model has been reasonably robust in explaining the pattern of sales for products as varied as videocassette recorders, color television sets, and personal computers.[24]

The goal of a diffusion model is to understand the shape of consumer adoption and hence the evolution of the industry. Naturally, there can be many competitors in an industry jockeying for market share. A diffusion model shows TAM, which assumes that one company can garner all of the market. How the market is divided is also crucial.

Detailed studies of product and industry life cycles show that there are typically three stages in industry evolution.[25] During the first stage, the number of competitors grows. For example, the number of firms grew from a handful to about 75 in the U.S. automobile industry in this stage. In the second stage there is a large shakeout as the result of a high number of firms exiting, which means that the number of competing firms declines sharply. In autos, the number dropped to about 20. Finally, the number of competitors, and often market shares, stabilize in the third stage.

This can be relevant for an assessment of a company's potential because in stage two, a company's sales can grow faster than the market itself if the number of competitors declines. Consider a new industry that has sales of $100 split equally among 10 competitors. Say that as the industry goes through stage two, sales rise to $200 while the number of firms drops to 5. As the industry's sales doubled, the potential amount of sales quadrupled for the survivors.

Estimating parameters for the Bass model. The output of any diffusion model is only as good as the parameters you use, so we now turn to an approach to estimating the parameters of the Bass model. The primary way to do this is through analogy. For example, you might assume that the adoption of satellite television is analogous to the adoption of cable television.

Of course, finding proper analogies is tricky. Even if products are alike in some regards, they will be different in other ways. There should be no expectation that the diffusion process of one product will comport exactly with another.

Exhibit 5 summarizes various microeconomic factors that provide a solid basis for finding appropriate analogies.[26] The specific process is to select a handful of products that are candidates as good analogies, and score them on the factors in the exhibit. The score allows you to assess which products or services are most akin to the one you are modeling and therefore provides a starting point for the appropriate parameters. It may also be useful to weight multiple products to reflect the blend of their characteristics.[27]

Exhibit 5: Basis for Comparing Products to Identify Strength of Analogy

Basis of Analogy	Candidates Product 1	Product 2	Product 3
Economic situation			
Economic	______	______	______
Technological	______	______	______
Political	______	______	______
Regulatory	______	______	______
Ecological	______	______	______
Social	______	______	______
Market structure			
Market potential	______	______	______
Sales history	______	______	______
Barriers to entry	______	______	______
Number of generic competitors	______	______	______
Type of generic competitors	______	______	______
Segmentation	______	______	______
Buyer behavior			
Buying situation	______	______	______
Decision process	______	______	______
Choice attributes	______	______	______
Buying center	______	______	______
Marketing strategy			
Product	______	______	______
Price	______	______	______
Promotion	______	______	______
Distribution	______	______	______
Characteristics of innovation			
Relative advantage	______	______	______
Compatibility	______	______	______
Complexity	______	______	______
Divisibility	______	______	______
Communicability	______	______	______

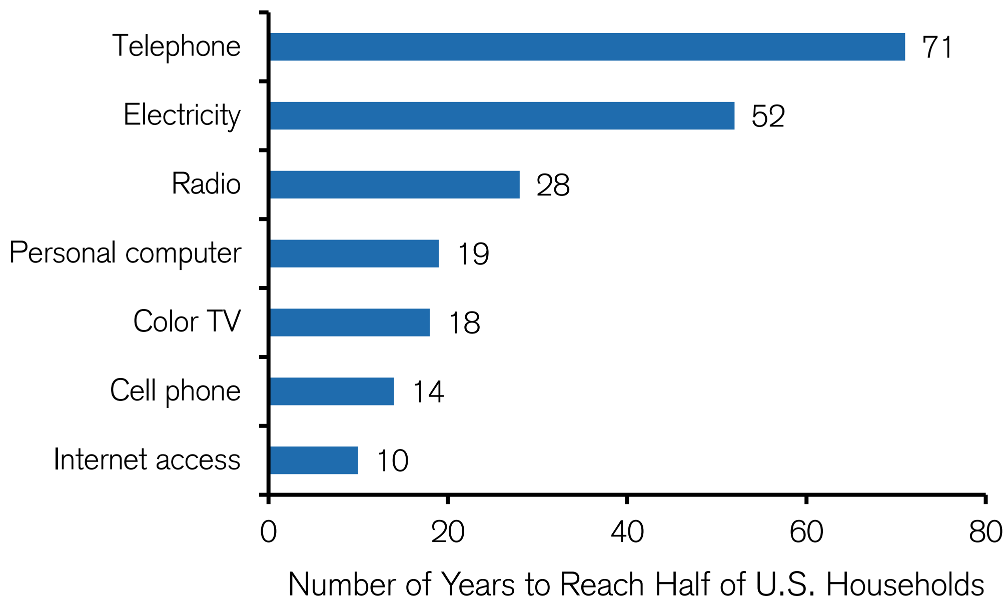
Source: Robert J. Thomas, "Estimating Market Growth for New Products: An Analogical Diffusion Model Approach," Journal of Product Innovation Management*, Vol. 2, No. 1, March 1985, 48.*

Appendix B summarizes a case study on the adoption of satellite radio.[28] The authors, Elie Ofek, a professor of marketing at Harvard Business School, and Peter Wickersham, a research associate, estimate the size of the market, m, based on assumptions about radio and subscription prices and calculate weighted averages for p and q based on the characteristics of analogous products.

We have a lot of data on the parameters for past diffusions, but many of those cases are dated. Further, research shows that there has been an acceleration in the rate of diffusion. For example, an innovation that reached 5 percent household penetration in 1946 took an estimated 13.8 years to go from 10 to 90 percent adoption. Innovations reaching 5 percent penetration in 1980 took only 6.9 years to achieve the same level of penetration.[29] And these are both before the advent of personal computers, the Internet, and mobile communication.

Exhibit 6 shows how long it took half of U.S. homes to adopt a number of significant new technologies. For example, it took 71 years for half of U.S. households to have a telephone and 52 years for electricity, but only 19 years for a personal computer and 10 years for Internet access.[30] New technologies not only have obvious primary benefits but also ancillary effects that ripple through the economy.

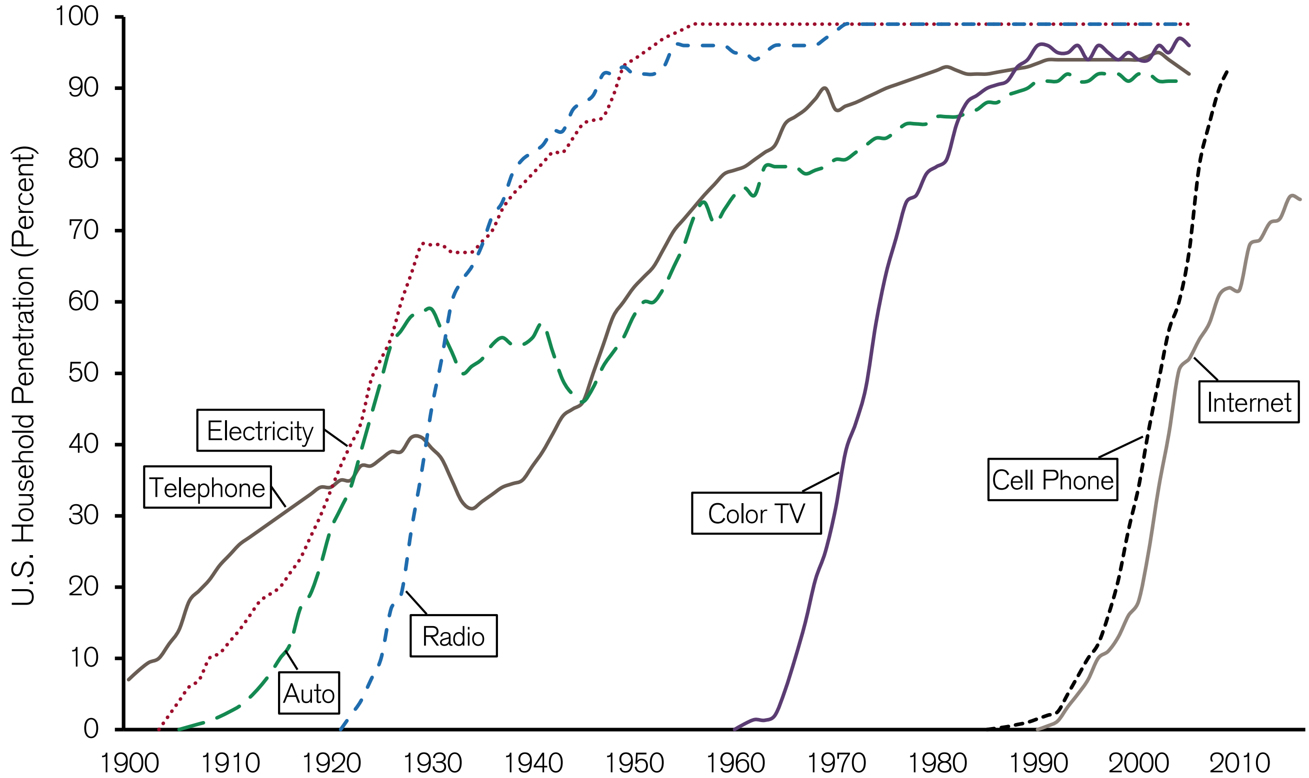
Exhibit 6: The Rate of Diffusion of New Technologies



Source: Adam Thierer and Grant Eskelsen, "Media Metrics: The True State of the Modern Media Marketplace," The Progress & Freedom Foundation, *Summer 2008, 18.*

Exhibit 7 shows the full rate of diffusion for seven important goods and services. Casual visual inspection shows that the slope of S-curves is steeper in recent times than it was in the past. The acceleration is especially pronounced for services. Consider that WhatsApp had 419 million users only 4 years after its launch. That compares to 145 million for Facebook, 123 million for Gmail, 54 million for Twitter, and 52 million for Skype over the same amount of time.[31]

Exhibit 7: The Rate of Diffusion Is Speeding Up



Source: Asymco, see: www.docs.google.com/spreadsheets/d/1uvn7o1X19Equ5EDvjXEMxpziAEAsXTJK9Xbf8NwYiAo/htmlview.

Limitations of the Bass Model

Use of a diffusion model can be very helpful in judging the TAM and the rate of adoption of a new good or service. Academics and consultants have shown the model's value in forecasts and have established a solid foundation of empirical parameters to guide judgments. But the model does have some limitations that don't allow it to capture certain considerations that are vital to anticipating corporate results.

We will focus on three areas. The first is the importance of replacement cycles. This is especially relevant in forecasting revenue growth. Next we consider economies of scale. As we have emphasized all along, TAM is not about size, it's about the size at which a company can create shareholder value. And finally there is the role of network effects. Here, we see lopsided market share distributions and increasing returns for the winners.

Replacement cycle. The Bass model is used primarily to forecast adoption of a product. But once a consumer buys something once, the next question is how frequently he or she will replace the product. Do you get a new smartphone every time a new product is announced? Or are you content to hold on to last year's model so long as it's working fine?

Frank Bass discussed the repurchase rate in his early research, but the topic has drawn less attention than the basics of the diffusion model itself.[32] Appendix C has a detailed discussion of the role of replacement cycles in product demand. The main point is that unit demand can fall, even with a rise in population and penetration rate, if the replacement cycle lengthens. At a certain point of maturity, the replacement cycle becomes an essential component of demand. This is relevant for TAM as companies and analysts seek to assess total sales potential.

Economies of scale. A company enjoys economies of scale when its cost per unit for key tasks, including purchasing, production, distribution, sales, and service, declines as volume increases.[33] Economies of scale can be a vital source of competitive advantage, and therefore value creation, but you must be mindful of its limits. Getting bigger isn't always consistent with greater economies of scale. This means that companies commonly fail to create value beyond a certain size, practically limiting the level of TAM.

In this context, Bruce Greenwald, a professor of finance and economics at Columbia Business School, stresses that "all strategy is local."[34] By this he means that companies can enjoy economies of scale on a local or regional basis, but as the company grows, fulfilling its theoretical TAM, its ability to create incremental value dissipates rapidly.

Greenwald uses the retail industry as an example, and Wal-Mart is his primary case study.[35] The company established its strength in the 1970s through the mid-1980s by being superior to its competitors in inbound logistics, advertising, and executive supervision. These advantages were largely the result of geographic concentration. This allowed the company's stores and distribution centers to be tightly clustered, the advertising dollars to have an impact on lots of stores, and the management to have the ability to effectively oversee operations without having to span the country. The case study shows that when Wal-Mart expanded beyond its local strengths, its return on capital and competitive advantage eroded.

Greenwald shows that there is a high correlation between local market share for retailers, reflecting geographic concentration, and profitability. This lesson is relevant not only for retailers that rely on physical stores, but also for any business that relies on local distribution. If a company rolls trucks to serve its customers, geographic concentration is important.

A separate issue, although with similar implications, is when companies "overshoot" their markets.[36] This relates to the theory of disruptive innovation that Clayton Christensen developed. One of the concepts of the theory is that companies improve their product or service at a rate that is faster than what the market demands. Eventually, customers get more than they need and are therefore unwilling to pay for additional product enhancements. Two symptoms of an overshot market are that customers use only a fraction of the functionality the product offers, and they are averse to paying for new features.

Companies serving overshot markets are vulnerable in two ways. The first is companies that are investing to improve performance, if even for competitive reasons, find that the customers are reticent to pay for such improvements. This crimps profitability. Second, the market becomes open to what Christensen calls "disruptive innovations." These innovations are typically cheaper and simpler, and satiate the demands of only the least discerning customers. But the performance of these innovations improves rapidly, allowing them to appeal to mainstream consumers quickly. Disruptive innovations rely on a different business model than the incumbents and almost always have a lower cost structure.

As a result, companies in overshot markets eventually get into a bind. They can't go upmarket to achieve greater profitability because the customer won't pay more. At the same time, they can't go downmarket because they run into the disruptive innovators that have lower costs. These companies are stuck.

A proper consideration of TAM includes the potential size of the market as well as the constraints to creating value. To add value over the long run, a company must have a competitive advantage. Economies of scale are one source of competitive advantage, but it is extremely difficult for companies with physical assets to achieve scale on a national or international basis. Further, companies can get to the point where they have overshot the market, which precludes them from moving upmarket while creating value.

Network effects. Network effects exist when the value of a good or service increases as more people use that good or service.[37] The classic example is the telephone. If you are the only one with a phone, it is of no value. But as more people acquire one, the value of each phone rises. Metcalfe's law, which is more a guideline than a law, suggests the total value of a network, where n is the number of members, is proportional to $n^2 - n$.

Most of the products in Appendix A do not benefit from network effects in a meaningful way. Whether your neighbor has a blender or air conditioning doesn't affect the value of those products for you. Even hub-and-spoke networks, such as airlines, have limited network effects. However, the rise of the Internet and mobile communications has made network effects more relevant in recent decades. The key is that these are combinatorial networks, where the nodes can communicate with one another.[38]

Consider the back-and-forth between Aswath Damodaran and Bill Gurley on the value of Uber. You can best describe Uber as a platform company that derives its value from network effects. For example, more users attract more drivers, and more drivers create more coverage and lower prices for the users, which creates additional demand, and so forth. Other classic examples of companies benefitting from network effects include Visa, eBay, Instagram, and Skype.

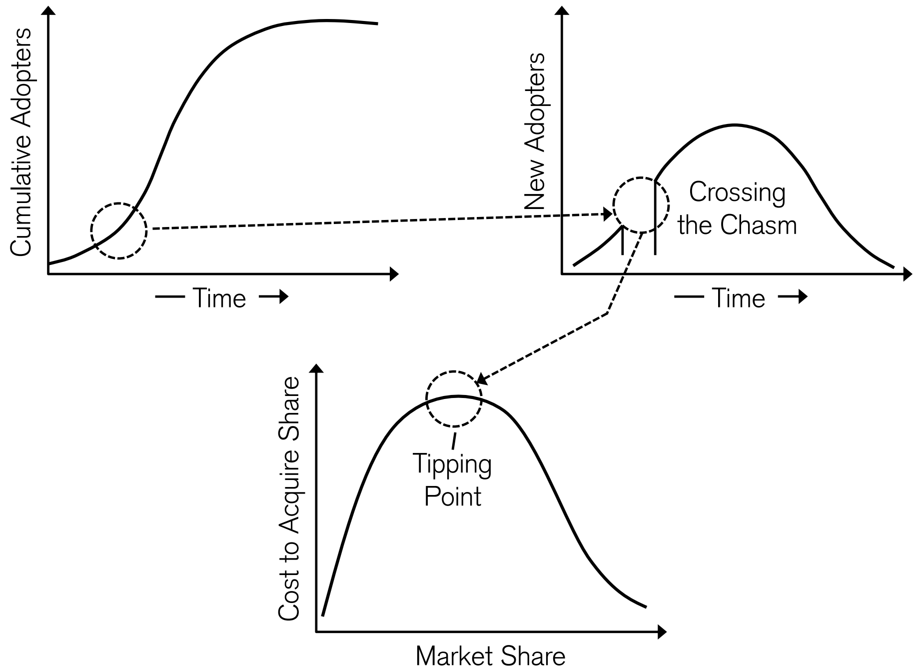
In cases where network effects are strong, it is common for one network to become dominant. For most consumer products, including athletic shoes, soft drinks, and automobiles, the market share of the leading company rarely tops 40 percent.[39] But in businesses with strong network effects, market shares are generally well above 50 percent and commonly closer to 90 percent. Examples include Microsoft's historical share of personal computer operating systems, eBay's share of online auctions, and Google's share of Internet searches.

W. Brian Arthur, an economist who has studied the networked economy extensively, likes to say, "Of networks, there will be few."[40] From a practical point of view, this means that companies will fight early on to become the network of choice, often spending great sums of money to do so.

Companies allocate resources in the hope that their product will beat their competitors and diffuse through the population. But Geoffrey Moore, a consultant to technology companies, has shown that in sectors with strong network effects, most companies fail to go from early adopters to mainstream users. Using Moore's memorable phrase, they are unable to "cross the chasm."[41]

Exhibit 8 adds two elements to the diffusion process we have discussed. This is relevant where strong network effects are in place. The first, in the upper right corner, is the fact that the products of most companies don't diffuse through the population. The second, at the bottom, is that while the cost to add users may be high in the early phase of network formation, the cost per user drops rapidly once a network becomes dominant.

Exhibit 8: Network Effects: The Cost to Acquire Users Drops for the Winner

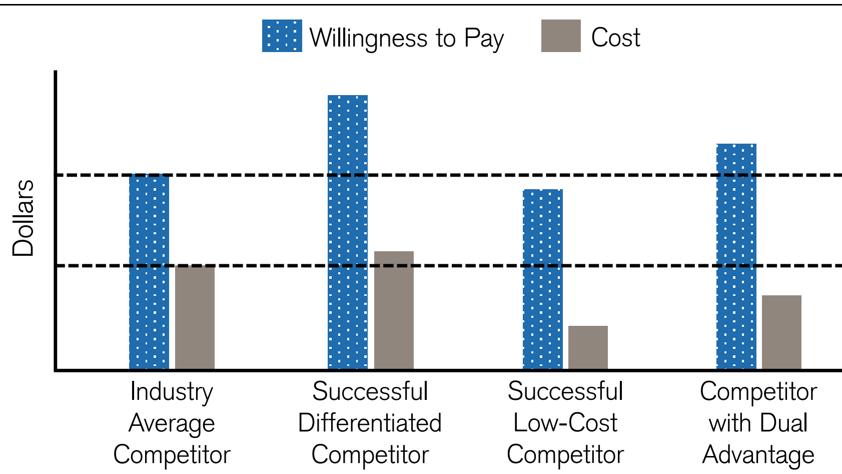


Source: Credit Suisse.

Why are Uber and its competitors, including Lyft, spending so aggressively today to attract users to their networks? Because these companies realize that one network is likely to emerge as dominant, which will allow for rapid growth and high returns on invested capital. This is what Brian Arthur calls the "*active* management of increasing returns."[42]

Central to the emergence of such an attractive business model is the fact that the winner benefits from economies of scale on both the supply and demand side. A company's ability to create value is the difference between its sales and costs, including the cost of capital.[43] As exhibit 9 shows, a company can increase value by reducing costs or raising prices. Research shows that differences in the prices customers are willing to pay better explains profit variability among competitors than differences in cost structures.[44]

Exhibit 9: Cost and Differentiation



Source: Pankaj Ghemawat, Strategy and the Business Landscape, Third Edition *(Upper Saddle River, NJ: Prentice Hall, 2010), 51.*

The concept of economies of scale has been around for a long time. The standard cost curve shows that as a manufacturing company increases output, its marginal and average unit costs decline up to a point. For these companies, the positive feedback is driven by increased sales. This is called supply-side scale because the more the company supplies, the lower is its cost per unit. This is classic increasing returns to scale.

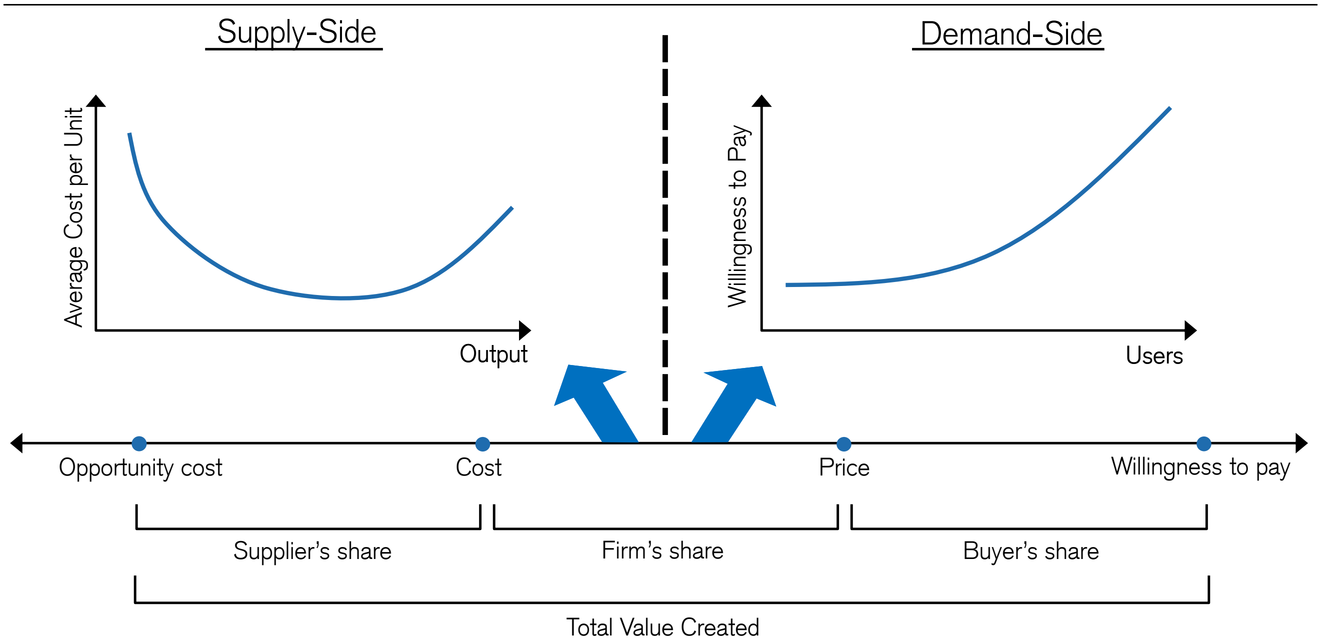
This positive feedback tends to dissipate as the result of growing bureaucracy and complexity, or input scarcity. (See the left side of Exhibit 10.) This generally happens at a level well before dominance. As we have noted, market shares in the industrial world rarely top 40 percent.

For combinatorial networks, network effects are the primary source of positive feedback. Rather than being driven only by supply, network effects are driven by demand as well. Specifically, the value to the users increases sharply once a network passes critical mass. Regardless of the cost of the supplier, customers are willing to pay more for the good or service because the network is more valuable to them.

Companies that win network battles enjoy lower costs as the result of supply-side scale and increase the value to the users as the network grows. If the company chooses not to raise prices in line with the increased willingness to pay, the company creates large consumer surplus. These are the dual advantages in exhibit 9. Exhibit 10 shows how these drivers affect a company's total value created.

Take Google as an example. Charlie Munger, vice chairman of Berkshire Hathaway, said, "Google has a huge new moat. In fact I've probably never seen such a wide moat."[45] Google's market share of global internet searches is close to 70 percent on all devices, and is about 90 percent on mobile and tablet devices. The vast number of queries provides strong advertising revenue, which in turn allows the company to enjoy economies of scale. At the same time, the business can invest in search technology and hence add value for users.

Exhibit 10: Supply- and Demand-Side Economies of Scale



Source: Credit Suisse.

The value of the networks that have been successful in recent years relies more on information than physical assets. This is significant for considering the nature of costs. Information goods generally have high upfront costs but very low incremental costs. Think of software. Writing code the first time is costly. But once finished, the cost of replicating and distributing the code is modest.

The combination of network effects and the cost characteristics of information goods can create a large amount of value in a relatively short period of time. A surge in sales, driven by network effects, along with low incremental costs can lead to substantial cash flow using only a modest amount of capital. A handful of network-based businesses have garnered valuations in the billions relatively quickly.

Networks based on information also benefit from classic economies of scale. The combination of network effects and low variable costs is what creates substantial positive leverage in operating profit margins. Exhibit 11 offers a simple example. Company A has low fixed costs but high variable costs. As sales volume grows, the operating profit margin rises, but the total gain is limited to 30 percentage points. Company B, has high fixed costs but enjoys substantially more leverage in operating profit margins, which improve by more than 50 percentage points.

Exhibit 11: Cost Structure Composition and Operating Profit Scalability

Company A **Cost structure: 25% fixed, 75% variable**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Units	500,000	1,000,000	1,500,000	2,000,000
Sales ($10.00 per unit)	5,000,000	10,000,000	15,000,000	20,000,000
Fixed costs	2,000,000	2,000,000	2,000,000	2,000,000
Variable costs	3,000,000	6,000,000	9,000,000	12,000,000
Total costs	5,000,000	8,000,000	11,000,000	14,000,000
Operating profit	0	2,000,000	4,000,000	6,000,000
Operating profit margin	0.0%	20.0%	26.7%	30.0%

Company B **Cost structure: 75% fixed, 25% variable**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Units	500,000	1,000,000	1,500,000	2,000,000
Sales ($10.00 per unit)	5,000,000	10,000,000	15,000,000	20,000,000
Fixed costs	3,500,000	3,500,000	3,500,000	3,500,000
Variable costs	583,330	1,166,660	1,749,990	2,333,320
Total costs	4,083,330	4,666,660	5,249,990	5,833,320
Operating profit	916,670	5,333,340	9,750,010	14,166,680
Operating profit margin	18.3%	53.3%	65.0%	70.8%

Source: Credit Suisse.
Note: Cost structure based on 1 million units.

Base Rates as a Reality Check

The third method in the triangulation process to estimate TAM is a careful consideration of base rates. The idea is to refer to what happened to other companies when they were in a situation similar to the one you are examining. No reference class is perfect, of course, but the base rate of performance can lend a vital point of view on the plausibility of a TAM estimate. Indeed, research shows that using base rates generally improves the accuracy of forecasts.[46]

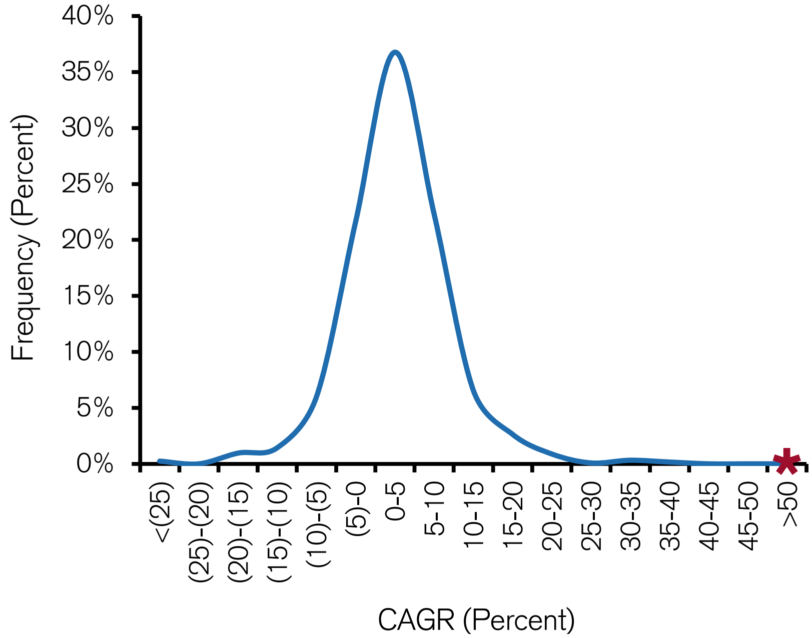
Here's an example of how the base rate approach can figure into your judgment of TAM. During a conference call in February 2015, Elon Musk, the chairman and chief executive officer (CEO) of Tesla Motors, suggested the company might be able to achieve a 50 percent compound annual growth rate of sales for the next decade off of a roughly $6 billion revenue base in 2015.[47]

You can start checking the plausibility of that growth rate by considering the population, product, and conversion method. You would consider the size of the global automobile market, estimate the share for electric cars in ten years, project Tesla's market share, and make some assumptions about vehicle prices. You would go through a similar process for the company's battery business. In other words, you would do a reality check through a bottom-up analysis.

Next, you might consider the diffusion literature. The automobile industry has a rich history, including the rate at which innovations such as automatic transmissions, air conditioning, and radial tires have permeated the industry.[48] You might complement these analogies with transformations in other industries, including the migration from traditional handsets to smartphones.

The base rate method takes a totally different approach. It simply asks: "What happened to other companies when they were in a comparable position?" Exhibit 12 shows the distribution of 10-year sales growth rates for more than 1,200 instances of companies of a similar size as Tesla is now, measured by sales. The average growth rate, adjusted for inflation, is less than three percent, with a standard deviation below eight percent. Further, no companies achieved a compound annual growth rate (CAGR) in excess of 40 percent (and the difference between 40 and 50 percent is enormous over a decade). We have placed a star at the growth rate Musk mentions.

Exhibit 12: 10-Year Growth Rates for Companies with $6-13 Billion of Sales



Source: Michael J. Mauboussin and Dan Callahan, "The Base Rate Book – Sales Growth," Credit Suisse Global Financial Strategies*, May 4, 2015.*

Even in cases where the first two approaches to estimating TAM would seem to justify rapid growth, you should temper the forecast against what experience shows is plausible. Might Tesla achieve this growth rate? Of course, it's possible. But what probability is reasonable to assign to such a scenario? A prudent investor would keep it very low. Such a growth rate is about six standard deviations away from the average, given the sample of recent history. Base rates provide a check on the output of the first two approaches to estimating TAM.

TAM and Ecosystems

When Jack Welch retired as the CEO of General Electric (GE) in September 2001, the company had a lower share of its TAM than when he assumed the job 20 years before. Executives estimated that GE's share of its TAM in 2001 was less than 10 percent, half of what it was in the early 1980s.

GE's businesses performed well during Welch's tenure. The drop in share was the result of redefining the TAM to be much larger in 2001 than it was in 1981. The key to the expanded definition is the notion of "linking and leveraging," or "transferring a user base built up upon one node of the ecology (one product) to neighboring nodes or products."[49] The phrase the "internet of things" reflects this opportunity.[50]

Increasingly, companies seek to place their products or services at the heart of an ecosystem. Done successfully, this creates three specific benefits. First, it allows the company to take advantage of network effects. Second, it encourages customers to remain within the ecosystem, making the customer economics attractive.[51] Finally, it extends a company's period of competitive advantage.[52]

One way to assess a company's ability to link and leverage is to consider three distinct business categories: physical, service, and knowledge.[53] Although the activities of most companies fall into more than one category, our objective is to understand the economic characteristics of each and to consider how companies can expand across them. Here are the categories:

- **Physical.** Tangible assets, including manufacturing facilities, stores, and inventory, are the main source of cash flows for these businesses. Think of steel producers and retailers. Sales growth is tied closely to asset growth.

- **Service.** People are the main source of competitive advantage for service businesses. The essential element is that companies in this category deliver their services on a one-to-one basis. Examples include law firms, advertising agencies, and consulting firms. Sales growth is tied to the number of employees and productivity.

- **Knowledge.** Knowledge businesses also rely on people as the main source of competitive advantage. Unlike service businesses, however, these companies create intellectual content once and then reproduce it. Think of software or biotechnology companies. Because the cost of replication is often low, there is no direct link between sales and costs, which creates the potential for the business to scale rapidly.

It is important to consider carefully how these business categories differ in their economic characteristics (see Exhibit 13). Some salient considerations include the following:

- **Source of advantage.** While physical companies depend on tangible assets, both service and knowledge businesses rely on people. So, as a business extends beyond its reliance on physical assets, it must learn to manage physical and human capital. Further, employees who are integral to the process of value creation commonly want to share the upside of the value they create. So, appropriate compensation arrangements and mobile internal labor markets are essential elements in achieving success.

- **Investment trigger.** Physical and service businesses grow by adding capacity, whether through capital expenditures or new employees. For instance, a retail chain must build new stores to generate sales growth in excess of what the current stores can deliver. Or a law firm needs new lawyers to produce additional sales. Naturally, physical and service businesses seek to maximize productivity, but the nature of the businesses limits the ability to scale.

By contrast, knowledge businesses generally invest to deal with obsolescence. While there are generally few constraints on selling more of a current product, the rate of change for knowledge industries is typically high. This means that there is little or no residual value for an outdated knowledge good.

Software is a good example. A company that comes up with a popular product can fulfill demand cheaply and profitably, and enjoys substantial economies of scale. But the value of the old product plummets when a better one comes out. Companies with an established user base can migrate their customers from one of their products to the next, therefore mitigating the risk of obsolescence.

- **Products and protecting capital.** Economists distinguish between rival and nonrival goods. A rival good is one where one person's consumption reduces the consumption of others. Pens and shirts are rival goods, because only one person can use them at a time. In jurisdictions with strong property rights, rival goods are straightforward to protect. A nonrival good is one that many people can use at the same time. It is essentially a formula or recipe. Think of a song on iTunes. Nonrival goods are generally difficult to protect because they are relatively easy and cheap to replicate. So the creator of a nonrival good often has difficulty capturing the value that he or she produces. Again, the music industry is a good example.

Exhibit 13: Characteristics of Various Business Categories

	Physical	**Services**	**Knowledge**
Source of advantage	Assets	People	People
Investment trigger	Capacity	Capacity	Obsolescence
Scalability	Low	Low	High
Products	Rival	Mixed	Nonrival
Protecting capital	Easy	Hard	Hard
Economies of scale	Supply-side	Supply-side	Demand-side

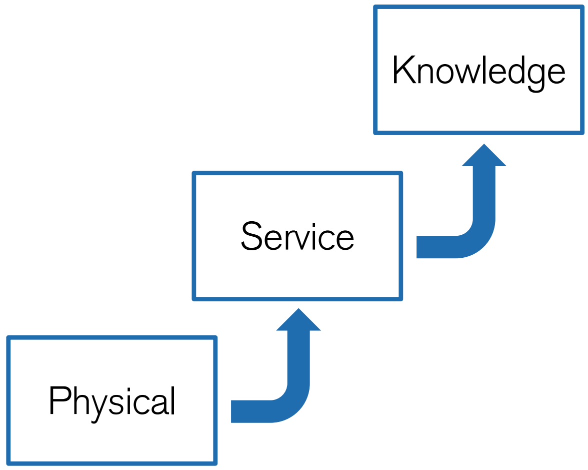
Source: Alfred Rappaport and Michael J. Mauboussin, Expectations Investing: Reading Stock Prices for Better Returns *(Boston, MA: Harvard Business School Publishing, 2001), 139.*

One strategy companies have used to increase their TAM, especially those reliant on physical assets, is to extend into new business categories (see Exhibit 14). This is how GE's share of TAM dropped even as its business was growing. GE Healthcare, for instance, expanded beyond selling x-ray, computerized axial tomography, and magnetic resonance imaging machines by offering multi-vendor service and, ultimately, remote diagnostics.

Deere & Company is another case in point. Deere is known for its tractors, mowers, and combines with the signature green bodies and yellow wheels. That is the physical category. But the machines are getting much smarter. As one Deere executive noted, "Today's large John Deere tractors have more lines of software code than early space shuttles [and Deere's] GPS technology can guide a tractor and implement in the field with near-perfect precision."[54]

In recent years Deere has reached beyond the machines into the service and knowledge categories. The company launched MyJohnDeere.com to allow farmers to be more efficient. The site helps farmers manage their equipment (service) and provides information about irrigation systems, nutrient sources, weather conditions, crop prices, and commodity futures (knowledge).

Exhibit 14: Business Category Evolution



Source: Credit Suisse.

Business category evolution not only has important implications for understanding TAM, it also presents a number of important strategic challenges for businesses.[55] These include trade-offs between open and closed systems, functionality in the product or in the cloud, determining which party owns the data, and whether or not to monetize data by selling to outside parties.

Summary

Total addressable market is a vital indicator of a company's potential, as it measures how large a company can grow to be while still creating shareholder value. TAM is a concept that is commonly discussed by companies and investors but is rarely thoughtfully quantified.

We use the process of triangulation to estimate TAM, with methods that include a basic assessment of the population, product, and conversion, a diffusion model, and a check through the application of appropriate base rates. Indeed, approaching the problem from multiple points of view likely provides valuable context and prevents common errors.

Companies are increasingly seeking to build ecosystems around their goods or services, which if successful take advantage of network effects, improve customer retention, and extend the competitive advantage period. But it is important to bear in mind that few companies win the battle of networks. Most fail.

Business category evolution is one way to think about how companies can build ecosystems around existing products or services. For example, manufacturers of physical goods, such as Deere & Company, are extending into service and knowledge businesses. Or think of Google, primarily a knowledge business, purchasing Motorola Mobility, a physical business, to extend its ecosystem.

TAM is an area where overconfidence and optimism are rife. We have provided some analytical approaches to check these biases and to come up with a reasonable assessment of whether the market's expectations are reasonable.

Checklist for Estimating a Total Addressable Market

Categorizing New Products

- [ ] Is the product technology new or current?
- [ ] Are the customers new or current?

Market Size

- [ ] Are the users and payers of the good or service the same?
- [ ] How much money do the buyers have?
- [ ] Are the resources of buyers growing or shrinking?
- [ ] Are there physical limitations, such as how much one can eat or use a product, that can curb demand?
- [ ] What is the elasticity of demand?
- [ ] How cyclical is demand?
- [ ] How do consumers allocate their time and money now and how might that change?
- [ ] Are the suppliers and sellers of the good or service the same?
- [ ] What is the business's production capacity?
- [ ] Is there a reliable infrastructure to get the goods or services to market?
- [ ] How broad is the geographical footprint?
- [ ] Where is the industry in its life cycle? What does that imply about the growth rate and pricing flexibility?
- [ ] Does manufacturing capacity match the rate of growth in demand?
- [ ] Is the company using pricing as a lever to drive scale or to increase profitability?
- [ ] Are there existing or potential economic or social regulations that could limit TAM?
- [ ] What are management's incentives and are they aligned with shareholders?
- [ ] Are there economies of scale? Local? National? International?
- [ ] Are there two or more competitors, which could push each company into a separate niche?

TAM and the Bass Model

- [ ] Which stage of the life cycle is the company's industry in?
- [ ] What analogous products can inform your estimates for the Bass Model parameters?

Limitations of the Bass Model

- [ ] When a consumer buys something once, how frequently does he or she replace it (repurchase rate)?
- [ ] Has the company's good or service overshot the market? Might that happen soon?
- [ ] Does the company have a competitive advantage that will allow for value creation over time?
- [ ] Do network effects exist?

Consider Base Rates

- [ ] What happened to other companies when they were in a situation similar to the one you are examining?
- [ ] Are your TAM estimates plausible when considering these base rates?

TAM and Ecosystems

- [ ] Does the company operate primarily a physical, service, or knowledge business?
- [ ] What is the company's source of advantage?
- [ ] What are the investment triggers?
- [ ] Does the company sell rival or nonrival goods?
- [ ] Are there opportunities to extend into new business categories?

Appendix A: Sampling of Factors That Explain Historical Diffusion Processes

Exhibit 15: Empirical Parameters for Bass Model

Product/Technology	Period of Analysis	p	q	m
Agricultural				
Tractors (thousands of units)	1921-1964	0.000	0.134	5,201.0
Hybrid corn	1927-1941	0.000	0.797	100.0
Artificial insemination	1943-1959	0.028	0.307	73.2
Bale hay	1943-1959	0.013	0.455	92.2
Medical Equipment				
Ultrasound imaging	1965-1978	0.000	0.534	85.8
Mammography	1965-1978	0.000	0.729	57.1
CT scanners (50-99 beds)	1980-1993	0.044	0.350	57.9
CT scanners (>100 beds)	1974-1993	0.036	0.268	95.0
Production Technology				
Oxygen steel furnace (USA)	1955-1980	0.002	0.435	60.5
Oxygen steel furnace (France)	1961-1980	0.008	0.279	88.4
Oxygen steel furnace (Japan)	1959-1975	0.049	0.333	81.3
Steam (vs. sail) merchant ships (UK)	1815-1965	0.006	0.259	86.7
Plastic milk containers (1 gallon)	1964-1987	0.020	0.255	100.0
Plastic milk containers (half gallon)	1964-1987	0.000	0.234	28.8
Stores with retail scanners (FRG, units)	1980-1993	0.001	0.605	16,702.0
Stores with retail scanners (Denmark, units)	1986-1993	0.076	0.540	2,061.0
Electrical Appliances				
Room air conditioner	1950-1979	0.006	0.185	60.5
Bed cover	1949-1979	0.008	0.130	72.2
Blender	1949-1979	0.000	0.260	54.5
Can opener	1961-1979	0.050	0.126	68.0
Electric coffee maker	1955-1979	0.042	0.103	100.0
Clothes dryer	1950-1979	0.009	0.143	70.1
Clothes washer	1923-1971	0.016	0.049	100.0
Coffee maker ADC	1974-1979	0.077	1.106	32.2
Curling iron	1974-1979	0.101	0.762	29.9
Dishwasher	1949-1979	0.000	0.213	47.7
Disposer	1950-1979	0.000	0.179	50.4
Fondue	1972-1979	0.166	0.440	4.6
Freezer	1949-1979	0.019	0.000	94.2
Frypan	1957-1979	0.142	0.000	65.6
Hair dryer	1972-1979	0.055	0.399	51.6
Hot plates	1932-1979	0.056	0.000	26.3
Microwave oven	1972-1990	0.002	0.357	91.6
Mixer	1949-1979	0.000	0.134	97.7
Power leaf blower (gas or electric)	1986-1996	0.013	0.315	26.0
Range	1925-1979	0.004	0.065	63.6
Range, built-in	1957-1979	0.048	0.086	21.7
Refrigerator	1926-1979	0.025	0.126	99.7
Slow cooker	1974-1979	0.000	1.152	34.4
Steam iron	1950-1979	0.031	0.128	100.0
Toaster	1923-1979	0.038	0.000	100.0
Consumer electronics				
Cable television	1981-1994	0.100	0.060	68.0
Calculators	1973-1979	0.143	0.520	100.0
Camcorder	1986-1996	0.044	0.304	30.5
CD player	1986-1996	0.055	0.378	29.6
Cellular telephone	1986-1996	0.008	0.421	45.1
Cordless telephone	1984-1996	0.004	0.338	67.6
Electric toothbrush	1991-1996	0.110	0.548	14.8
Home PC (millions of units)	1982-1988	0.121	0.281	25.8
Radio	1922-1934	0.027	0.435	100.0
Telephone answering device	1984-1996	0.025	0.406	69.6
Television, black and white	1949-1979	0.108	0.231	96.9
Television, color	1965-1979	0.059	0.146	100.0
VCR	1981-1994	0.025	0.603	76.3
Average		**0.037**	**0.327**	
Median		**0.025**	**0.280**	

Source: Gary Lilien, Arvind Rangaswamy, and Christophe Van den Bulte, "Diffusion Models: Managerial Applications and Software," ISBM Report 7-1999, *May 20, 1999.*

Appendix B: Satellite Radio Case Study

We show how to use the Bass model to forecast total demand for an industry by sharing the key findings of a Harvard Business School case study. Professor Elie Ofek and Peter Wickersham, authors of the case, explain how to forecast demand for the U.S. satellite radio industry by coming up with appropriate approximations for the parameters of the Bass model. They estimate the size of the market, *m*, based on assumptions about radio and subscription prices, and then establish the coefficient of innovation (*p*) and coefficient of imitation (*q*) using judgments about satellite radio's degree of similarity to related products. We compare these forecasts in the case study to the actual demand for satellite radio in the industry's first 13 years.

Estimating Market Size (*m*). The first step is to estimate the total market size, or *m*. Some markets are easier to assess than others. An example of a straightforward estimate is a new drug therapy that targets a specific disease (consistent with Exhibit 2). You can confidently estimate the size of that market by figuring out how many people have the disease and how many are likely to be diagnosed. The potential demand for most products or services is not as clear, particularly for those based on new technologies.

A useful place to start is a survey that gauges consumer interest and the likelihood of purchase. Robert Acker, the director of strategic planning for XM Satellite Radio (XM) in the late 1990s, commissioned this market research for the U.S. satellite radio industry. The national telephone survey included more than 6,000 people. Acker designed the survey to provide useful information for XM's general strategy. For example, he sought input on how best to target customers and how to position the service to be attractive.

The survey also provided crucial insight into who might pay for the service and how much they might be willing to pay. XM had yet to determine its primary market, so Acker conducted the survey for radios in the car and at home. Ofek and Wickersham's case study focuses on the car radio, then seen as the most likely market to succeed.

Based on the survey results, Acker was able to make reasonable estimates for total demand based on the cost of the radio in the car and the monthly subscription fee. We summarize the results in exhibit 16. For example, the projected demand is about 49 million customers for a radio price of $150 and a subscription price of $5 per month. The wide range of outcomes shows the importance of sensitivity analysis. In the case, Ofek and Wickersham assume *m* is 30 million based on a radio price of around $250 and a subscription price of about $10.

Exhibit 16: Projected Demand at Different Price Levels for Car Radio and Subscription

Demand in millions	Subscription Price				
Radio Price	**$2**	**$5**	**$8**	**$10**	**$12**
$100	77.8	68.3	58.7	54.0	45.7
$150	53.0	49.1	44.1	41.6	35.6
$200	42.8	40.5	37.8	36.5	31.5
$250	32.6	31.8	31.2	30.7	26.6
$300	29.1	28.9	28.7	28.5	24.8
$400	27.7	27.6	27.5	27.4	23.7

Source: Elie Ofek, "Forecasting the Adoption of a New Product," Harvard Business School Case Study 9-505-062*, December 12, 2013.*

Estimating *p* and *q*. The next step is to estimate the coefficient of innovation (*p*) and coefficient of imitation (*q*). One common approach is to identify similar products and assume that the parameters will be comparable for your product.

As exhibit 5 shows, there are multiple characteristics you can use to assess comparability. Ofek and Wickersham advise that you should at a minimum choose analogies based on product and market characteristics. Additional elements to consider include the overall economic conditions, buyer behavior, marketing strategy, and characteristics of the innovation. If no product serves as a perfect analogy, it is useful to consider several similar products. This is the approach the authors follow for satellite radio, and they ultimately settle on three products: the portable CD player, the automobile radio, and the cellular phone.

The next step is to search for the published estimates of the parameters for the analogous products. Appendix A provides estimates for a wide range of products, and you can find additional figures in other studies.

In the case study, Ofek and Wickersham weight the importance of market structure and product characteristics to come up with estimates for *p* and *q*. Specifically, they weight product characteristics 60 percent and market structure 40 percent. This weighting assumes that physical features and content (product) are more important than a revenue model based on subscription (market). Exhibit 17 summarizes the assumptions of the authors.

Exhibit 17: Bass Model Forecast of Total Demand for Satellite Radio

Product	Market Structure (Similarity to Satellite Radio)	Weight	Weighted Value	Product Characteristics (Similarity to Satellite Radio)	Weight	Weighted Value	Weighted Score	Contri-bution	*p*	Weighted *p*	*q*	Weighted *q*
Portable CD Player	4 out of 10	0.4	1.6	7 out of 10	0.6	4.2	5.8	31.9%	0.006	0.002	0.660	0.210
Automobile Radio	8 out of 10	0.4	3.2	9 out of 10	0.6	5.4	8.6	47.3%	0.016	0.008	0.410	0.194
Cellular Phone	8 out of 10	0.4	3.2	1 out of 10	0.6	0.6	3.8	20.9%	0.008	0.002	0.421	0.088
						Sum	18.2		**Sum**	**0.011**	**Sum**	**0.492**

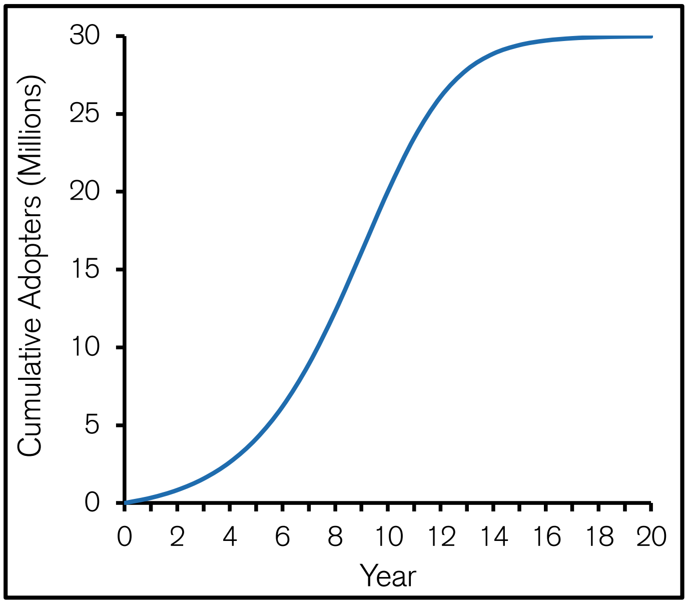
Source: Elie Ofek, "Forecasting the Adoption of a New Product," Harvard Business School Case Study 9-505-062*, December 12, 2013; Credit Suisse.*

To clarify the approach, let's use the example of the portable CD player. Ofek and Wickersham believe that based on market structure, the CD player has a similarity score of 4 out of 10. This means the weighted value is 1.6 (4.0 * 0.4). The score of similarity on product characteristics is 7 out of 10 for a weighted value of 4.2 (7.0 * 0.6). Combining the market structure and product characteristics gives the CD player a total weighted score of 5.8.

The authors follow the same approach for the other two products, and come to a total weighted score for all three products of 18.2. The weighted contribution of the CD player is 31.9 percent (5.8/18.2). So, the weighted *p* for the CD player is 0.002 (0.006*0.319), and its weighted *q* is 0.210 (0.660 * 0.319). The sum of the weighted results for all three products provides the estimated parameters for satellite radio of 0.011 for *p* and 0.492 for *q*.

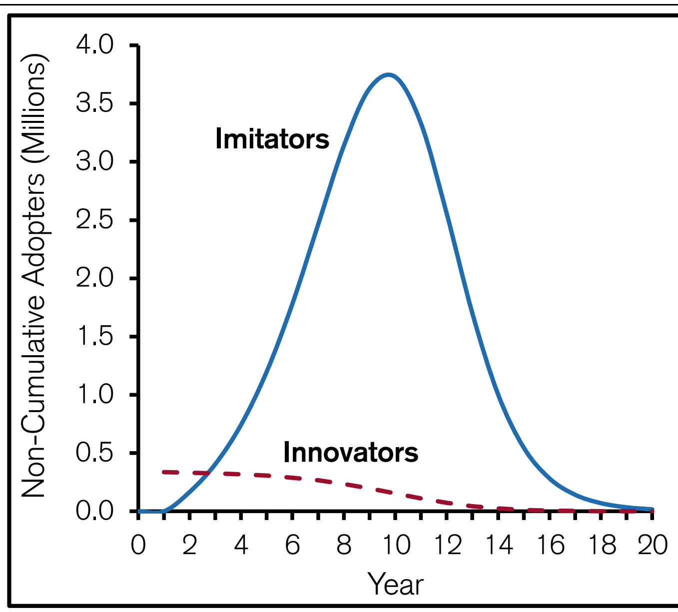
We can plug our estimates of *m*, *p*, and *q* into the Bass model to get a forecast of total demand over time (see Exhibit 18). Because the coefficient of innovation, *p*, is much lower than the coefficient of imitation, *q*, the model suggests a slow rate of adoption at first followed by a rapid rise once the industry realizes critical mass. After a few years, imitators overwhelmingly drive adoption (see Exhibit 19).

Exhibit 18: A Bass Model Forecast of Total Demand for Satellite Radio



Source: Elie Ofek, "Forecasting the Adoption of a New Product," Harvard Business School Case Study 9-505-062*, December 12, 2013; Credit Suisse.*

Exhibit 19: Adoptions of Satellite Radio by Innovators and Imitators



Source: Elie Ofek, "Forecasting the Adoption of a New Product," Harvard Business School Case Study 9-505-062*, December 12, 2013; Credit Suisse.*

We can compare this forecast to the actual results by combining the subscriber bases of the two U.S. satellite radio companies, Sirius Satellite Radio and XM Satellite Radio. We have 13 years of data, as XM launched its service in late 2001 and Sirius in early 2002. They were separate companies until they merged in 2008.

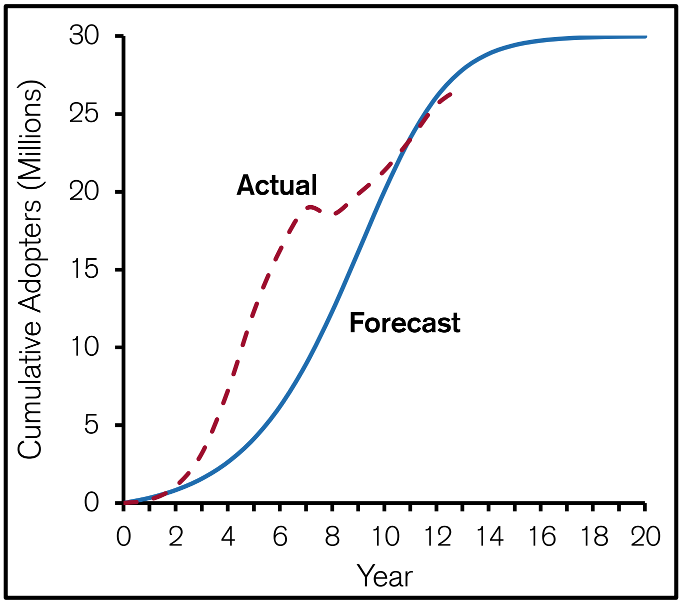
The Bass model forecast was off the mark for the initial trajectory of demand, but proved remarkably prescient in its long-term forecast of users. In the most recent year (through the third quarter of 2014), the forecast differed from the actual results by only 1.1 million users, or about 4 percent (see Exhibit 20).

The parameters also allow us to estimate the peak sales:

$$\text{Size of peak sales} = m\left[\frac{(p+q)^2}{4q}\right] = 30\left[\frac{(0.011 + 0.492)^2}{4*0.492}\right] = 3.9 \text{ million}$$

This forecast, too, was very accurate, predicting peak annual subscriber growth of 3.9 million, consistent with the actual outcome you can see in exhibit 19.

Exhibit 20: Demand for Satellite Radio—Bass Model Forecast versus Actual



Source: Company reports; Elie Ofek, "Forecasting the Adoption of a New Product," Harvard Business School Case Study 9-505-062, *December 12, 2013; Credit Suisse.*

Appendix C: Diffusion and the Replacement Cycle *

In this appendix, we demonstrate the significance of the replacement cycle in understanding demand for an industry. When forecasting demand for a product or service, analysts tend to focus primarily on the rate of new adopters, or penetration. But the rate of new adopters is not the only thing that determines unit volumes over time.

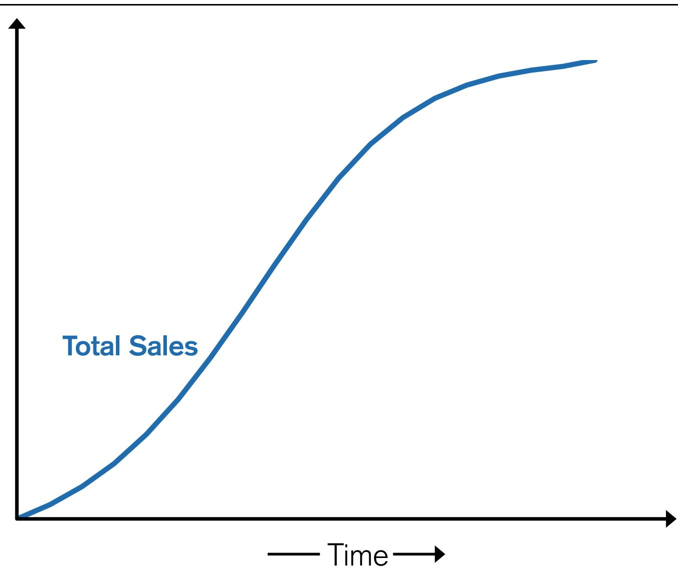
The rate at which customers replace their products, or the replacement cycle, can be just as meaningful as the rate of adoption. If the replacement cycle is shortening, customers are replacing their products faster. If it is lengthening, customers are taking more time between purchase and replacement. For most products, a time comes when replacement units are a majority of the total. And because products diffuse faster today, the replacement cycle quickly becomes an important consideration.

When replacements become a large portion of total demand, an interesting and counterintuitive thing can happen. If consumers expand the time between when they purchase and replace their products, total demand can decline even if there is continued growth in population and penetration. You still have plenty of customers making their first purchase, but this new demand is more than offset by a large existing base of users who are waiting longer between upgrades.

To understand when to prioritize new users and when to focus on the replacement cycle, it's useful to consider a simple three-stage model of the life of a product or service. The first stage is all about growth in new users. The second stage is transitional and marks when replacements exceed new users for the first time. Here the analysis requires a balance between new users and replacement demand. The length and change in the replacement cycle become essential inputs into a demand model. The third stage is maturity. The market is fully penetrated and the replacement cycle defines demand.

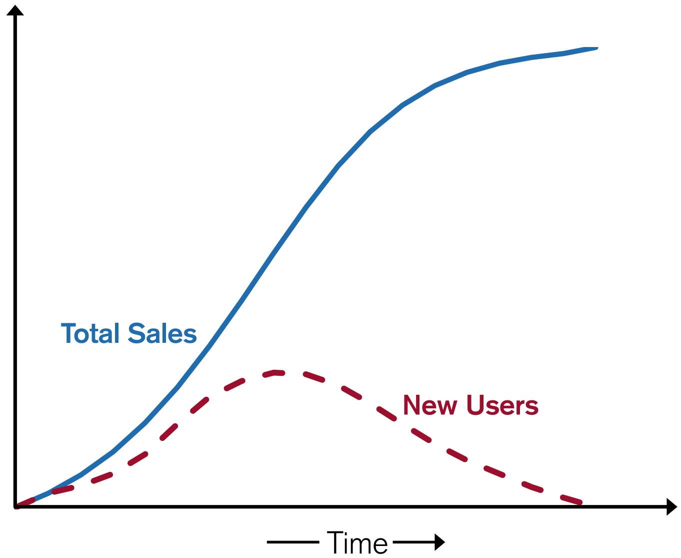
To set the stage for our analysis, we begin by illustrating the typical pattern of diffusion for an innovation. The pattern of cumulative users follows an S-curve (see Exhibit 21). While the S-curve shows cumulative product adoption, the plot of new adopters follows a normal distribution (see Exhibit 22).

Exhibit 21: Generic S-Curve



Source: Credit Suisse.

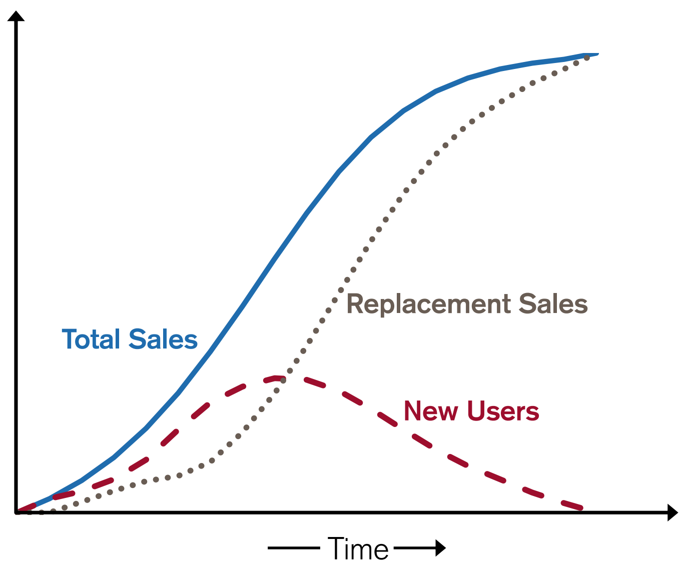
Exhibit 22: Cumulative and New Users



Source: Credit Suisse.

We now turn to replacement sales. It often doesn't take long for replacements to account for the majority of total unit sales (see Exhibit 23). Replacements become a majority of the total within five to seven years for many products and are the majority of demand for almost all industries within a dozen years. So, in a relatively short period of time, replacement cycles become the most important leading indicator of value.

Exhibit 23: Replacement Sales as a Percentage of Total Sales



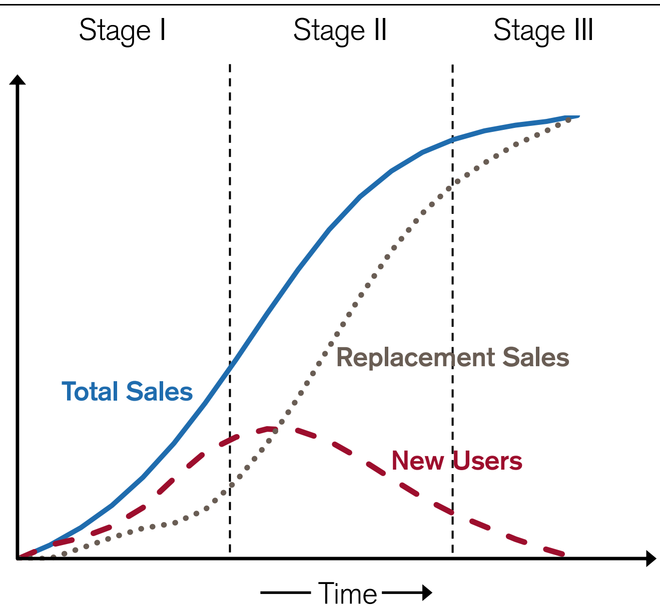
Source: Credit Suisse.

The Three Stages

Our next step is to break a product's life into three stages (see Exhibit 24):

- **Stage I—Penetration.** Here, the priority is to gain widespread acceptance and increase penetration of the new product or service. Replacement sales exist at this stage but their contribution is negligible. 3D printers are in this stage today.
- **Stage II—Transition.** In this stage, replacement demand exceeds demand from new users for the first time. Your analysis should shift from determining the rate of new user growth to assessing the length and potential change of the replacement cycle. Smartphones are in this stage today.
- **Stage III—Maturity.** With the market fully penetrated, unit sales are comprised nearly solely by replacement demand. Personal computers and laptops are in this stage today.

Exhibit 24: Three Stages of a Product's Life



Source: Credit Suisse.

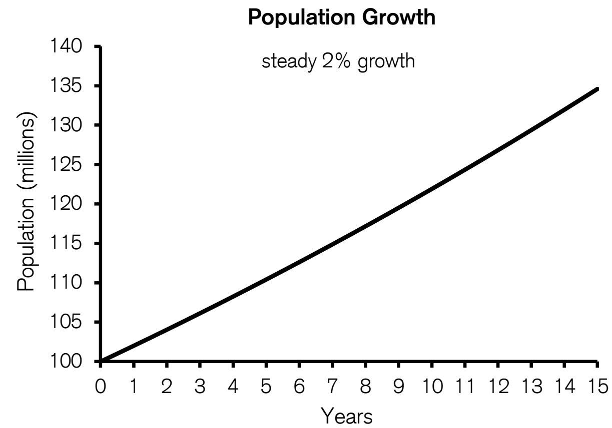
This progression from Stage 1 to Stage 3 suggests three important considerations. The first is the drivers of the replacement cycle. The second is whether or not the needs of customers change as a product matures (they do). The final, and arguably most critical, issue is how a shift in the replacement cycle affects total demand. Here, it is possible for the decline in demand for replacement sales as the result of an expanding replacement cycle to exceed the contribution of sales from new users.

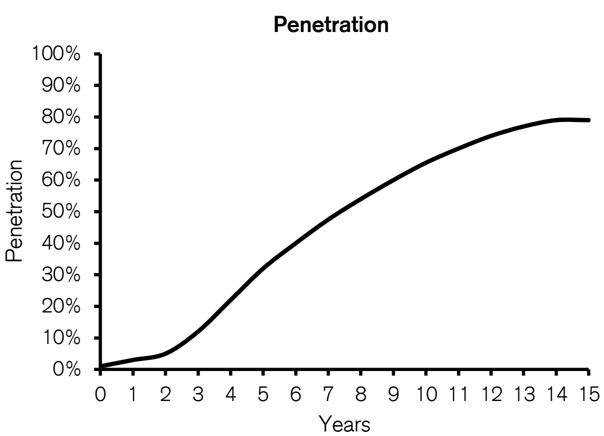
A simple example demonstrates the large impact of a change in the replacement cycle. Exhibit 25 shows two scenarios. They are exactly the same except that Scenario 1 assumes the replacement cycle remains at 3 years through all 15 years, while Scenario 2 assumes that the replacement cycle expands from 3 to 4 years following the fifth year.

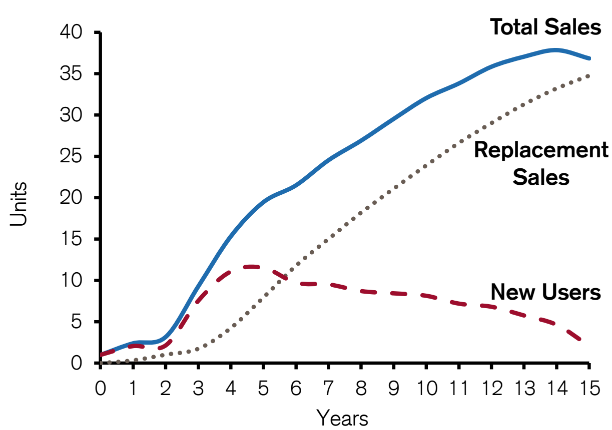
Exhibit 25: The Impact of a Lengthening Replacement Cycle

Scenario 1: Base Case

Replacement Cycle: 3 Years



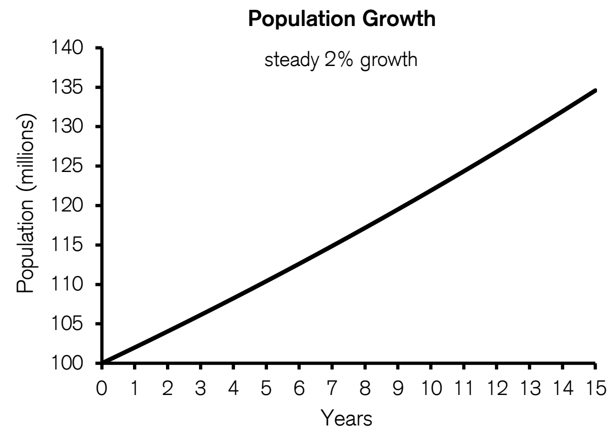


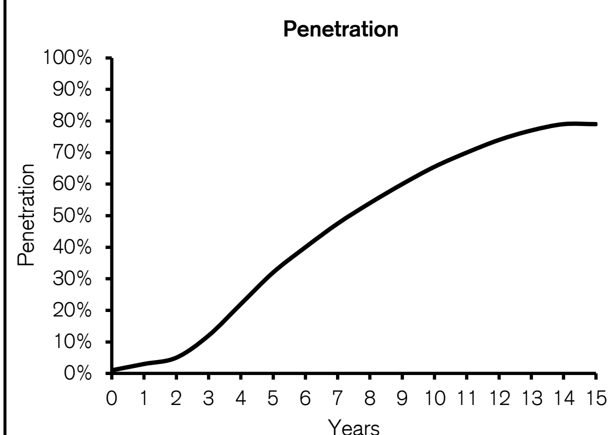


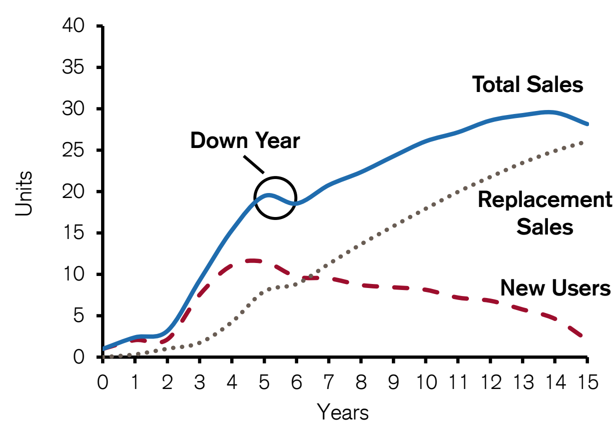
Cumulative units	366
Compound annual growth rate	27.2%

Scenario 2: Replacement Cycle Shift

Replacement Cycle: Shifts from
3 years to 4 years after Year 5







Cumulative units	305
Compound annual growth rate	24.9%

Source: Credit Suisse.

The example provides two key lessons. First, in Scenario 2 we see that total unit sales decline in year 6 despite continued growth in population and penetration. (Exhibits 26 and 27 show the data behind these charts.) Second, the seemingly modest shift from a three- to a four-year replacement cycle results in a material drop in long-term demand. Cumulative total unit sales decline by 17 percent versus the steady 3-year replacement cycle case, and the 15-year compound annual growth rate is 230 basis points lower.

This analysis of replacement cycles shows that a product can experience negative unit growth even when penetration is rising. This conclusion, while counterintuitive, reflects the fact that as an industry matures it becomes increasingly dependent on repeat purchases by its existing user base.

(*) = The idea behind this analysis came from Jay Freedman, founder and managing partner of Crystal Rock Capital Management, LLC. This appendix borrows heavily from Michael J. Mauboussin, Jay Freedman, Alexander Schay, and Christian Pitt, "Diffusion Confusion: The Rising Role of the Replacement Cycle," *Credit Suisse First Boston Equity Research*, August 1, 2001.

Exhibit 26: Base Case: Replacement Cycle Remains at Three Years

Population Growth	2%	
Price Depreciation	7%	
Replacement Cycle (yrs.)	3	*First 5 years*
Replacement Cycle (yrs.)	3	*After 5th year*

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Population	100.0	102.0	104.0	106.1	108.2	110.4	112.6	114.9	117.2	119.5	121.9	124.3	126.8	129.4	131.9	134.6
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Total Penetration	1%	3%	5%	12%	22%	32%	40%	48%	54%	60%	66%	70%	74%	77%	79%	79%
Cumulative penetration units	1.0	3.1	5.2	12.7	23.8	35.3	45.0	54.6	63.3	71.7	79.8	87.0	93.8	99.6	104.2	106.3
New Sales	1.0	2.1	2.1	7.5	11.1	11.5	9.7	9.5	8.7	8.4	8.1	7.2	6.8	5.8	4.6	2.1
Replacement sales		0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
			0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
				0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
					2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
						3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69
							3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84
								3.24	3.24	3.24	3.24	3.24	3.24	3.24	3.24	3.24
									3.17	3.17	3.17	3.17	3.17	3.17	3.17	3.17
										2.90	2.90	2.90	2.90	2.90	2.90	2.90
											2.81	2.81	2.81	2.81	2.81	2.81
												2.71	2.71	2.71	2.71	2.71
													2.40	2.40	2.40	2.40
														2.27	2.27	2.27
															1.92	1.92
																1.54
Replacement sales	0.0	0.3	1.0	1.7	4.2	7.9	11.8	15.0	18.2	21.1	23.9	26.6	29.0	31.3	33.2	34.7
Percent from penetration	100%	86%	68%	81%	72%	59%	45%	39%	32%	29%	25%	21%	19%	16%	12%	6%
Percent from replacement	0%	14%	32%	19%	28%	41%	55%	61%	68%	71%	75%	79%	81%	84%	88%	94%
TOTAL UNIT VOLUME	1.0	2.4	3.2	9.3	15.3	19.5	21.5	24.5	26.9	29.5	32.0	33.8	35.8	37.0	37.8	36.8
PRICE	100.0	93.0	86.5	80.4	74.8	69.6	64.7	60.2	56.0	52.0	48.4	45.0	41.9	38.9	36.2	33.7
MARKET SIZE	1.0	2.2	2.7	7.5	11.5	13.5	13.9	14.8	15.0	15.4	15.5	15.2	15.0	14.4	13.7	12.4
Unit volume growth		139%	32%	193%	65%	27%	10%	14%	10%	10%	9%	6%	6%	3%	2%	-3%
Market size growth		123%	23%	173%	54%	18%	3%	6%	2%	2%	1%	-2%	-1%	-4%	-5%	-9%

Source: Credit Suisse.

Exhibit 27: Modified Case: Replacement Cycle Goes from Three to Four Years after Year 5

Population Growth	2%	
Price Depreciation	7%	
Replacement Cycle (yrs.)	3	*First 5 years*
Replacement Cycle (yrs.)	4	*After 5th year*

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Population	100.0	102.0	104.0	106.1	108.2	110.4	112.6	114.9	117.2	119.5	121.9	124.3	126.8	129.4	131.9	134.6
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Total Penetration	1%	3%	5%	12%	22%	32%	40%	48%	54%	60%	66%	70%	74%	77%	79%	79%
Cumulative penetration units	1.0	3.1	5.2	12.7	23.8	35.3	45.0	54.6	63.3	71.7	79.8	87.0	93.8	99.6	104.2	106.3
New Sales	1.0	2.1	2.1	7.5	11.1	11.5	9.7	9.5	8.7	8.4	8.1	7.2	6.8	5.8	4.6	2.1
							***SHIFT to 4 year replacement cycle**									
Replacement sales		0.33	0.33	0.33	0.33	0.33	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
			0.69	0.69	0.69	0.69	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
				0.71	0.71	0.71	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
					2.51	2.51	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
						3.69	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
							2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88
								2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43	2.43
									2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38
										2.18	2.18	2.18	2.18	2.18	2.18	2.18
											2.11	2.11	2.11	2.11	2.11	2.11
												2.03	2.03	2.03	2.03	2.03
													1.80	1.80	1.80	1.80
														1.70	1.70	1.70
															1.44	1.44
																1.16
Replacement sales	0.0	0.3	1.0	1.7	4.2	7.9	8.8	11.3	13.6	15.8	17.9	20.0	21.8	23.5	24.9	26.1
Percent from penetration	100%	86%	68%	81%	72%	59%	52%	46%	39%	35%	31%	26%	24%	20%	16%	7%
Percent from replacement	0%	14%	32%	19%	28%	41%	48%	54%	61%	65%	69%	74%	76%	80%	84%	93%
TOTAL UNIT VOLUME	1.0	2.4	3.2	9.3	15.3	19.5	18.5	20.8	22.3	24.3	26.1	27.2	28.6	29.2	29.5	28.1
PRICE	100.0	93.0	86.5	80.4	74.8	69.6	64.7	60.2	56.0	52.0	48.4	45.0	41.9	38.9	36.2	33.7
MARKET SIZE	1.0	2.2	2.7	7.5	11.5	13.5	12.0	12.5	12.5	12.6	12.6	12.2	12.0	11.4	10.7	9.5
Unit volume growth		139%	32%	193%	65%	27%	-5%	12%	8%	9%	7%	4%	5%	2%	1%	-5%
Market size growth		123%	23%	173%	54%	18%	-11%	4%	0%	1%	0%	-3%	-2%	-5%	-6%	-11%

Source: Credit Suisse.

Endnotes

[1] Michael J. Mauboussin and Dan Callahan, "Measuring the Moat: Assessing the Magnitude and Sustainability of Value Creation," *Credit Suisse Global Financial Strategies*, July 22, 2013.
[2] Aswath Damodaran, "Uber Isn't Worth $17 Billion," *FiveThirtyEight*, June 18, 2014. Also, Evelyn M. Rusli and Kirsten Grind, "Wellington and Fidelity Expected to Lead Uber Investment," *Wall Street Journal*, June 3, 2014.
[3] Douglas MacMillan and Telis Demos, "Uber Valued at More Than $50 Billion," *Wall Street Journal*, July 31, 2015.
[4] Bill Gurley, "How to Miss By a Mile: An Alternative Look at Uber's Potential Market Size," *Above the Crowd*, July 11, 2014.
[5] Kenneth B. Kahn, *New Product Forecasting: An Applied Approach* (Armonk, NY: M.E. Sharpe, 2006), 5-18.
[6] J. Scott Armstrong and Kesten C. Green, "Competitor-oriented Objectives: The Myth of Market Share," *International Journal of Business*, Vol. 12, No. 1, Winter 2007, 115-134.
[7] Robert Strohmeyer, "The 7 Worst Tech Predictions of All Time," *PCWorld*, December 31, 2008. See http://www.techhive.com/article/155984/worst_tech_predictions.html.
[8] Arthur G. Cook, *Forecasting for the Pharmaceutical Industry: Models for New Product and In-Market Forecasting and How to Use Them* (Burlington, VT: Gower Publishing Company, 2006). Also, Lisa McIntyre, "Forecasting New Product Revenues," *L.E.K. Executive Insights*, Vol. 4, No. 2, March 1, 2001.
[9] Ryan Jaslow, "High Cholesterol Treatment Guidelines Push High-Dose Statins Over Lower Dose, Combo Treatments," *CBS News*, November 13, 2013. Also, "13 million more Americans would take statins if new guidelines followed: Study," *AP*, March 19, 2014.
[10] Terry A. Jacobson, M.D., "Noncompliance With Lipid-Lowering Therapy: Why We Should Strive to Improve Compliance," *Medscape Multispecialty.*
[11] Myoung Cha, Bassel Rifai and Pasha Sarraf, "Pharmaceutical Forecasting: Throwing Darts?" *Nature Reviews Drug Discovery*, Vol. 12, No. 10, October 2013, 737-738.
[12] There's an old joke along these lines. A fisherman walks into a store looking for lures. The store has a huge collection with a variety of shapes, sizes, and colors. The fisherman carefully examines the selection and finally asks the clerk, "Do fish really bite these things?" The clerk answers, "I don't know, I don't sell them to fish."
[13] Mauboussin and Callahan, "Measuring the Moat."
[14] Andrew Ross Sorkin, "BlackRock's Chief, Laurence Fink, Urges Other C.E.O.s to Stop Being So Nice to Investors," *New York Times DealBook*, April 13, 2015.
[15] Bruce Greenwald and Judd Kahn, "All Strategy Is Local," *Harvard Business Review*, September 2005, 94-104.
[16] Frank M. Bass, "A New Product Growth for Model Consumer Durables," *Management Science*, Vol. 15, No. 5, January 1969, 215-227. Note that the original title has a typographical error. Later, Bass commented on the error as follows, "Perhaps the first thing to notice about the paper that has come to be known as the "Bass Model" (Bass 1969) is the title. It contains a typo. The paper was published with the title: 'A New Product Growth for Model Consumer Durables.' The correct title should be: 'A New Product Growth Model for Consumer Durables.' I suppose that I was so excited about having the paper accepted for publication that I failed to carefully proofread the galley proofs." See Frank M. Bass, "Comments on 'A New Product Growth for Model Consumer Durables'," *Management Science*, Vol. 50, No. 12 Supplement, December 2004, 1833-1840.
[17] Everett M. Rogers, *Diffusion of Innovations, Fifth Edition* (New York: Free Press, 1985).
[18] Christophe Van den Bulte, "Want to Know How Diffusion Speed Varies Across Countries and Products? Try Using a Bass Model," *PDMA Visions*, Vol. 26, No. 4, October 2002, 12-15.
[19] Gary Lilien, Arvind Rangaswamy, and Christophe Van den Bulte, "Diffusion Models: Managerial Applications and Software," *ISBM Report 7-1999*, May 20, 1999.

[20] Also, see Geoffrey A. Moore, *Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers* (New York: HarperBusiness, 1991).
[21] Frank M. Bass, Kent Gordon, Teresa L. Ferguson, and Mary Lou Githens, “DIRECTV: Forecasting Diffusion of a New Technology Prior to Product Launch,” *Interfaces*, Vol. 31, No. 3, May-June 2001, S82-S93.
[22] Richard A. Michelfelder and Maureen Morrin, “Overview of New Product Diffusion Sales Forecasting Methods,” Appendix F in Gordon V. Smith and Russell L. Parr, *Intellectual Property: Valuation, Exploitation, and Infringement Damages, Fourth Edition* (Hoboken, NJ: John Wiley & Sons, 2005), 817-827.
[23] Vijay Mahajan, Eitan Muller, and Frank M. Bass, “New Product Diffusion Models in Marketing: A Review and Directions for Research,” *Journal of Marketing*, Vol. 54, No. 1, January 1990, 1-26.
[24] Frank M. Bass, “Diffusion Theory in Marketing: A Historical Perspective,” *Presentation*, 1999. See http://www.iprcorp.com/assets/CMAGFiles/bass.pdf.
[25] Steven Klepper and Elizabeth Graddy, “The Evolution of New Industries and the Determinants of Market Structure,” *RAND Journal of Economics*, Spring 1990, 27-44. Also, James M. Utterback, *Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change* (Boston, MA: Harvard Business School Press, 1994).
[26] Robert J. Thomas, “Estimating Market Growth for New Products: An Analogical Diffusion Model Approach,” *Journal of Product Innovation Management*, Vol. 2, No. 1, March 1985, 45-55.
[27] Dan Lovallo, Carmina Clarke, and Colin Camerer, “Robust Analogizing and the Outside View: Two Empirical Tests of Case-Based Decision Making,” *Strategic Management Journal,* Vol. 33, No. 5, May 2012, 496-512.
[28] Elie Ofek, “Forecasting the Adoption of a New Product,” *Harvard Business School Case Study 9-505-062*, December 12, 2013; David B. Godes and Elie Ofek, “XM Satellite Radio (A),” *Harvard Business School Case Study 9-504-009*, March 1, 2004.
[29] Christophe Van den Bulte, “New Product Diffusion Acceleration: Measurement and Analysis,” *Marketing Science*, Vol. 19, No. 4, Fall 2000, 366-380.
[30] Adam Thierer and Grant Eskelsen, “Media Metrics: The True State of the Modern Media Marketplace,” *The Progress & Freedom Foundation*, Summer 2008, 18.
[31] Seth Fiegerman, “Facebook to Buy WhatsApp for $16 Billion,” *Mashable,* February 19, 2014. See http://mashable.com/2014/02/19/facebook-whatsapp/.
[32] Brett R. Gordon, “A Dynamic Model of Consumer Replacement Cycles in the PC Processor Industry,” *Marketing Science*, Vol. 28, No. 5, September-October 2009, 846-867.
[33] It can be useful to distinguish between “operating leverage” and “economies of scale.” Operating leverage is relevant when a company has large preproduction costs. These costs dampen profitability at low levels of sales but operating profit margins increase as sales grow. “Economies of scale” exist when a company can pursue activities as it gets larger. So operating leverage depends both on preproduction costs and sales, whereas economies of scale are driven primarily by sales. See Alfred Rappaport and Michael J. Mauboussin, *Expectations Investing: Reading Stock Prices for Better Returns* (Boston, MA: Harvard Business School Press, 2001), 42-44.
[34] Greenwald and Kahn.
[35] Bruce Greenwald and Judd Kahn, *Competition Demystified: A Radically Simplified Approach to Business Strategy* (New York: Portfolio, 2005), 77-99.
[36] Clayton M. Christensen, *The Innovator’s Dilemma: When New Technologies Cause Great Companies to Fail* (Boston, MA: Harvard Business School Press, 1997). Also, Clayton M. Christensen, Erik A. Roth, and Scott D. Anthony, *Seeing What's Next: Using Theories of Innovation to Predict Industry Change* (Boston, MA: Harvard Business School Press, 2004), 161-165.
[37] Carl Shapiro and Hal R. Varian, *Information Rules: A Strategic Guide to the Network Economy* (Boston, MA: Harvard Business School Press, 1999),173-225.
[38] For a more complete taxonomy of networks, see Michael J. Mauboussin, “Exploring Network Economics,” *Mauboussin on Strategy*, October 11, 2004.

[39] Frank M. Bass, "A Dynamic Model of Market Share and Sales Behavior," in Stephen A. Greyser, ed., *Toward Scientific Marketing (Proceedings of the Winter Conference of the American Marketing Association, December 27-28, 1963)* (Chicago, IL: American Marketing Association, 1964), 263-276.
[40] W. Brian Arthur, "Myths and Realities of the High-Tech Economy," *Credit Suisse First Boston Thought Leader Forum*, September 10, 2000.
[41] Moore, 1991.
[42] W. Brian Arthur, "Increasing Returns and the New World of Business," *Harvard Business Review*, July-August 1996, 100-109.
[43] Adam M. Brandenburger and Harborne W. Stuart, Jr., "Value-Based Business Strategy," *Journal of Economics & Management Strategy*, Vol. 5, No. 1, Spring 1996, 5-24.
[44] Richard E. Caves and Pankaj Ghemawat, "Identifying Mobility Barriers," *Strategic Management Journal*, Vol. 13, No. 1, January 1992, 1-12.
[45] Alistair Barr, "Buffett, Munger Praise Google's 'Moat'," *MarketWatch*, May 3, 2009.
[46] Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus and Giroux, 2011), 245-254. Also, Michael J. Mauboussin and Dan Callahan, "The Base Rate Book – Sales Growth: Integrating the Past to Better Anticipate the Future," *Credit Suisse Global Financial Strategies*, May 4, 2015.
[47] Tesla Motors, Inc. Q4 2014 Earnings Call, February 11, 2015. See FactSet: callstreet Transcript, page 7. The conference call transcript actually says "30 percent" but if you work out Musk's math, the only way to get to a market capitalization basically "the same as Apple's is today" is to assume a 50 percent growth rate.
[48] Horace Dediu, "Is Tesla Disruptive?" *Asymco.com*, May 28, 2015.
[49] Arthur, "Increasing Returns and the New World of Business."
[50] Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Competition," *Harvard Business Review*, November 2014, 67-89.
[51] Frederick F. Reichheld, *The Loyalty Effect*: *The Hidden Force Behind Growth Profits and Lasting Value* (Boston, MA: Harvard Business School Press, 1996),
[52] Mauboussin and Callahan, "Measuring the Moat."
[53] Rappaport and Mauboussin, *Expectations Investing*, 136-140.
[54] Brian Tomlin, Aran Brosnan, and George Craft, "Deere & Company: The Global Operating Model and the Worldwide Harvesting Cab Initiative," *Tuck School of Business Case Study*, 2012.
[55] Porter and Heppelmann, "How Smart, Connected Products Are Transforming Competition."

CREDIT SUISSE

Important information