PRYSM GROUP

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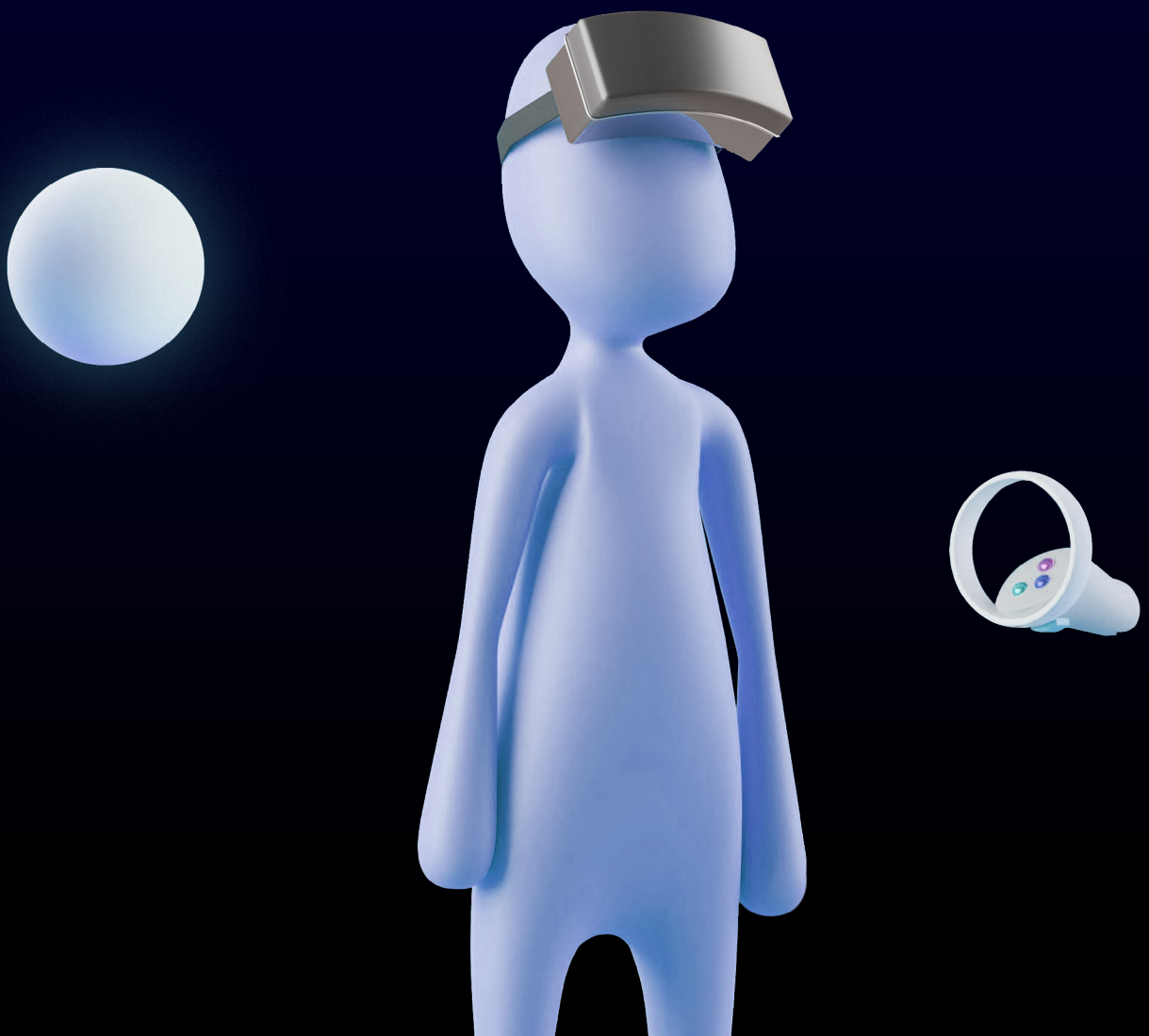
Technological Adoption: A Cost-Benefit Framework

White Paper



Economics of Emerging Technologies

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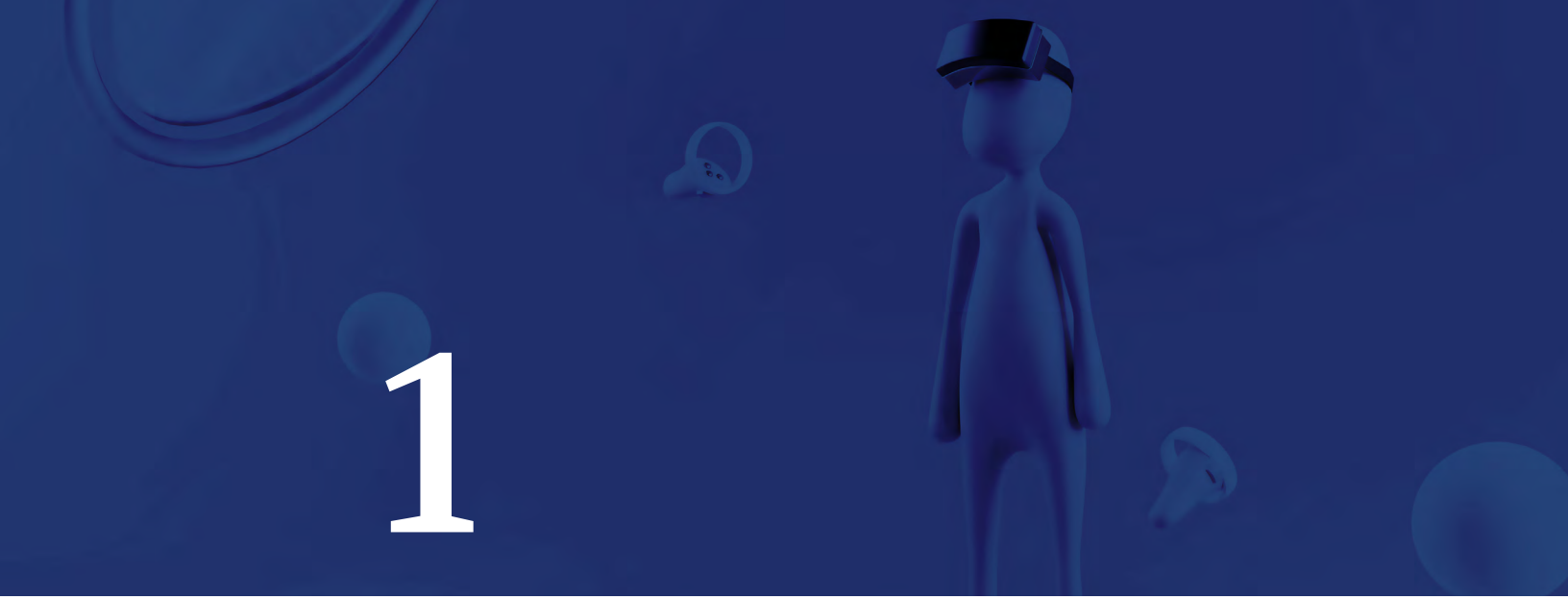


1

Introduction

Industry analysts regularly tout the seismic impact that various emerging technologies will have. Blockchain technology "could revolutionize the world economy," with implications that "are staggering, not just for the financial-services industry but also right across virtually every aspect of society."[1] Artificial Intelligence is already "transforming every walk of life," and has the potential to disrupt fields as wide-ranging as "finance, national security, health care, criminal justice, [and] transportation."[2] The Metaverse serves as a fundamentally "new evolution of the internet," and its impact on "education, healthcare, commerce and much more will be very real."[3]

Each of these predictions has compelling arguments in its favor. Yet if history is any guide, while some will be borne out, others will not.[4] This raises key questions: why do some promising technologies succeed in gaining widespread adoption, while others languish and ultimately fail? What can firms building products using new technologies do to increase the chances of success?

One way to explore these questions is to consider the economic incentives of businesses and individual consumers faced with the option of adopting a new technology. In general, customers will adopt a new technology if its expected benefits exceed its projected costs. It follows that a new technology can succeed by either mitigating costs relative to alternative options, providing superior benefits, or both. Technologies that fall short on both sides of the ledger will likely fail.

This seemingly simple heuristic gives rise to a number of difficult and important considerations. How are concrete, predictable costs weighed against uncertain, variable benefits? What if the timing of a technology's costs and benefits diverge significantly? When will a firm or consumer hold out adopting a clearly beneficial technology in favor of a potentially superior alternative on the horizon? And what role do network effects and ecosystems play in their decision-making?

In this reading, we explore how a cost-benefit framework can be applied to elucidate the key economic factors and decision points involved in the adoption of new technologies. No one can predict with certainty which technologies will succeed and which will fail. Nevertheless, a close examination of customers' decision-making surrounding technology adoption is critical for assessing the likelihood that a given technology will find an audience, and developing a go-to-market strategy that maximizes the odds of success.

2

The Benefits of New Technology Adoption

Three Benefits Offered by New Technologies

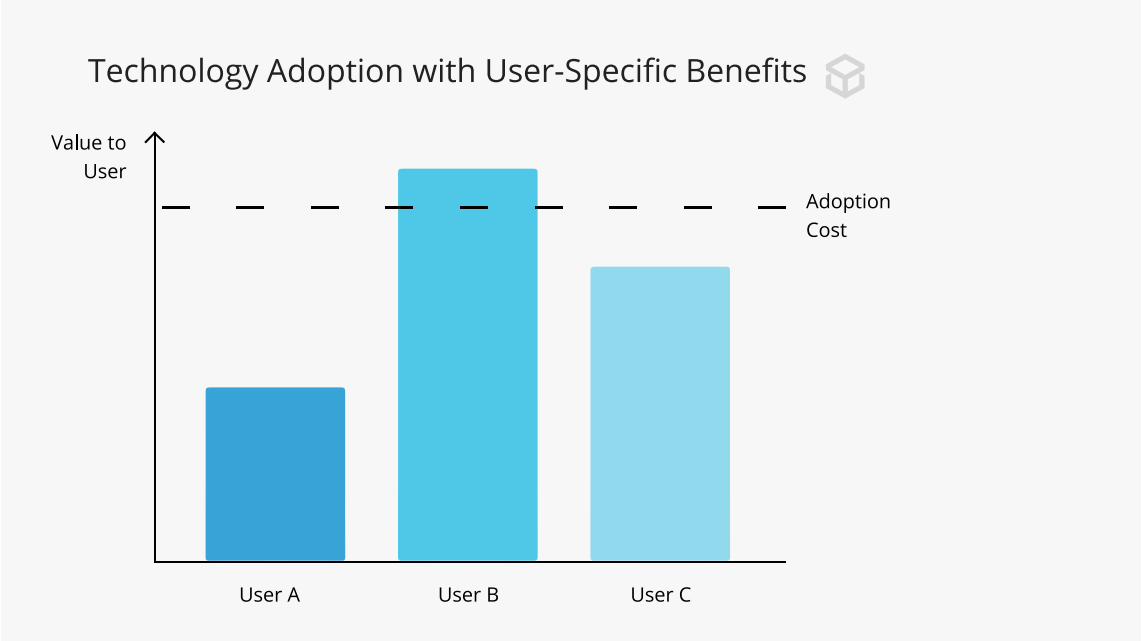
1. **Usage Value**	The utility that adopters derive from using the technology, including personal enjoyment, productivity, and increases in social capital.
2. **Network Effects**	The value of joining a robust network of other users who contribute to the value of the network as a whole.
3. **Ecosystem Advantages**	The value of gaining access to an extensive suite of auxiliary applications, services, and products.

New technologies can create value across three dimensions: **usage value**, **network effects**, and **ecosystem advantages**.

The usage value of a new technology is simply the utility that individuals derive from using it. The first mobile phones allowed users to make calls away from their landlines. Subsequent iterations introduced cameras, internet browsing, music, games, and a host of other features. In each case, users derived utility from making use of the technology's novel features. The higher the usage value of a technology-the more new features it introduces, and the more utility value users derive from each of them-the more willing users will be to purchase it. This is true as well in the workplace context, where "the degree to which a person believes that using a particular system would enhance his or her job performance," is one of the key factors motivating professional adoption of IT devices and applications.[5]

The utility that users derive from a given technology is not necessarily limited to its practical applications. Individuals' technology adoption decisions are often influenced by **subjective norms**, the beliefs and actions of others whose opinions the user values, as well as considerations regarding the effect their use of a particular technology will have on their social status within a particular group.[6]

Everett Rogers' well-known Diffusion of Innovations theory, which describes the consumer archetypes that adopt technologies at differing stages in their product lifecycle, highlights the importance of high-status **early adopters** in influencing peers to mimic their technology adoption decisions.[7] It follows that users will derive varying levels of utility from a given technology, depending upon their individual traits and the social groups surrounding them. A technology that consumers within a particular demographic or age cohort perceive to be highly beneficial may not appeal to others.



Network effects arise when the value of a product or platform to a given user increases with the number of other users who adopt it. **Direct network effects** are present where the value of a platform to a given user increases when users of the same type join the network. For instance, users of a particular social media platform benefit when other users join, as they have more users to interact and engage with. **Indirect network effects** are present in multi-sided platforms that connect users of different types. For example, buyers on the Facebook Marketplace platform benefit when more sellers join, while sellers benefit when more buyers join.

Providers of technologies that enjoy network effects can provide benefits to their user base simply by attracting new users. When Uber attracts new drivers, the value of its app to riders increases; when Etsy attracts new buyers, the value of its platform to sellers increases; and when Grubhub onboards new restaurants, the value of its platform to patrons increases. Network effects can serve both to attract new users to a platform, as well as mitigate user defection to alternative platforms. This dynamic typically results in a considerable advantage for first-movers and other incumbents, whose existing network can be difficult for competitors to replicate. Providers of new technologies and solutions can transcend their starting user deficit by offering subsidies and other benefits to early adopters.

3

Switching Costs, Network Effects, and Path Dependence

Costs of New Technology Adoption

1. Direct Financial Costs

Costs that require explicit cash outlays.

a. Hardware Investments

The utility that adopters derive from using the technology, including personal enjoyment, productivity, and increases in social capital.

b. Licensing and Subscriptions

The costs of purchasing a software license or gaining access to a subscription-based software platform.

2. Indirect or Nonfinancial Costs

Costs that may not require explicit cash outlays, but do require time or effort.

a. Switching Costs

i. IMPLEMENTATION COSTS

The costs required to switch from use of one technology to use of another, related to adapting existing systems and environments to accommodate the new technology.

ii. LEARNING CURVE COSTS

The costs required to switch from use of one technology to use of another, related to people's interaction with the technology.

b. Opportunity Costs

The cost of adopting today rather than waiting for the emergence of a superior alternative in the future.

3. Auxiliary Risks

Other hazards associated with adoption.

a. Platform Risk

The risk that a particular platform upon which a consumer or firm comes to rely ultimately fails.

b. Lock-in

The risk that a consumer or firm will be locked in to a suboptimal technology or standard due to high switching costs.

Adopting new technologies often entails a range of direct financial costs, indirect or nonfinancial costs, and auxiliary risks.

Direct financial costs include the costs of procuring hardware and software. The form and timing of these direct costs vary based on the characteristics of the technology itself, and the revenue model of its provider. Hardware may be purchased outright, leased, or purchased on a financed basis. It may also carry periodic maintenance, support, and upgrade costs. Software licenses may similarly be purchased outright in exchange for an upfront fee, though providers have increasingly been moving to a Software-as-a-Service (SaaS) model, whereby users are given access to a web-hosted platform in exchange for a periodic subscription fee.

Indirect or nonfinancial costs, by contrast, often do not require an explicit outlay of cash, but nonetheless play a critical role in technology adoption decisions. A primary class of indirect costs are **switching costs**, which are all the costs required to switch from use of one technology to use of another.[8] Within this category are **implementation costs**, which are the costs associated with adapting existing systems in order to accommodate the new technology. This would include the cost to a plant of reorganizing its production line for a particular piece of new manufacturing equipment, the cost to an individual consumer of canceling a contract with one mobile service provider in favor of entering into a new agreement with a different provider, and the cost of converting data from one format to another. Switching to a new technology may also carry substantial **learning curve** costs, requiring adopters to expend time and resources adjusting to its use. Whether formal training is required for workers to utilize a new technology, or consumers must adapt to new gestures and habits, most new technologies require some type of behavioral change. Firms and individuals may be loath to adopt a new technology that requires extensive practice or training before it can be used effectively, even if this does not involve an explicit cash outlay.

Another indirect cost associated with adopting a new technology is the opportunity cost associated with investing in a particular technology rather than waiting for a new version or a superior alternative to emerge. iPhone users who lack the financial resources to upgrade each year face this dilemma in perpetuity: does one invest in the latest iPhone that has been released, or wait for the next version, which promises even more features and benefits? Assuming one's resources are finite, even in the absence of switching costs, upgrading to the latest technology today can foreclose adoption of an upgraded or alternative technology in the near future.

Finally, adopting a new technology carries a number of auxiliary risks that customers factor into their decision-making. One such risk is platform risk, which is the risk that a particular platform upon which a consumer or firm relies ultimately fails. A manufacturing firm that manages its supply chain through a particular SaaS solution will likely face significant disruptions if the provider of that platform goes out of business, or suddenly decides to cease supporting it. A consumer may similarly be left in a difficult position if a platform in which they have invested time and resources loses developer support and no longer grants access to a dynamic ecosystem. The prospect that a particular platform will fail or lose support is a critical risk for any adopter.

Another key risk is the prospect that, by adopting a particular technology, users will be locked in to using it for an extended period, typically due to high switching costs. Users may be hesitant to lock themselves into a new technology with high switching costs if they believe it may ultimately prove to be suboptimal, or will be superseded in quality by a competitor.

Historically, a number of inferior technologies have maintained widespread adoption simply because the costs of switching from them to a superior alternative were sufficiently high, a phenomenon that economists term **path dependence**. Perhaps the most famous case of this phenomenon is the standard QWERTY keyboard layout, which some argue owes its market-wide dominance merely to the high switching costs users face in learning a new layout, rather than any intrinsic features of its design.[9] At the level of the individual firm, the prospect of being locked into an inferior standard represents a significant risk, and will make firms reluctant to adopt new technologies with overly high switching costs.

4

Weighing Costs & Benefits

The costs of a new technology are often easier to estimate than its benefits. Consider a firm determining whether to upgrade to a new subscription-based Enterprise Resource Planning (ERP) software. As discussed, a variety of implicit switching costs are involved in this decision, and these may be difficult to quantify. Yet at least one cost-the recurring subscription fee-is known with certainty, and can be projected into the future with reasonable accuracy.

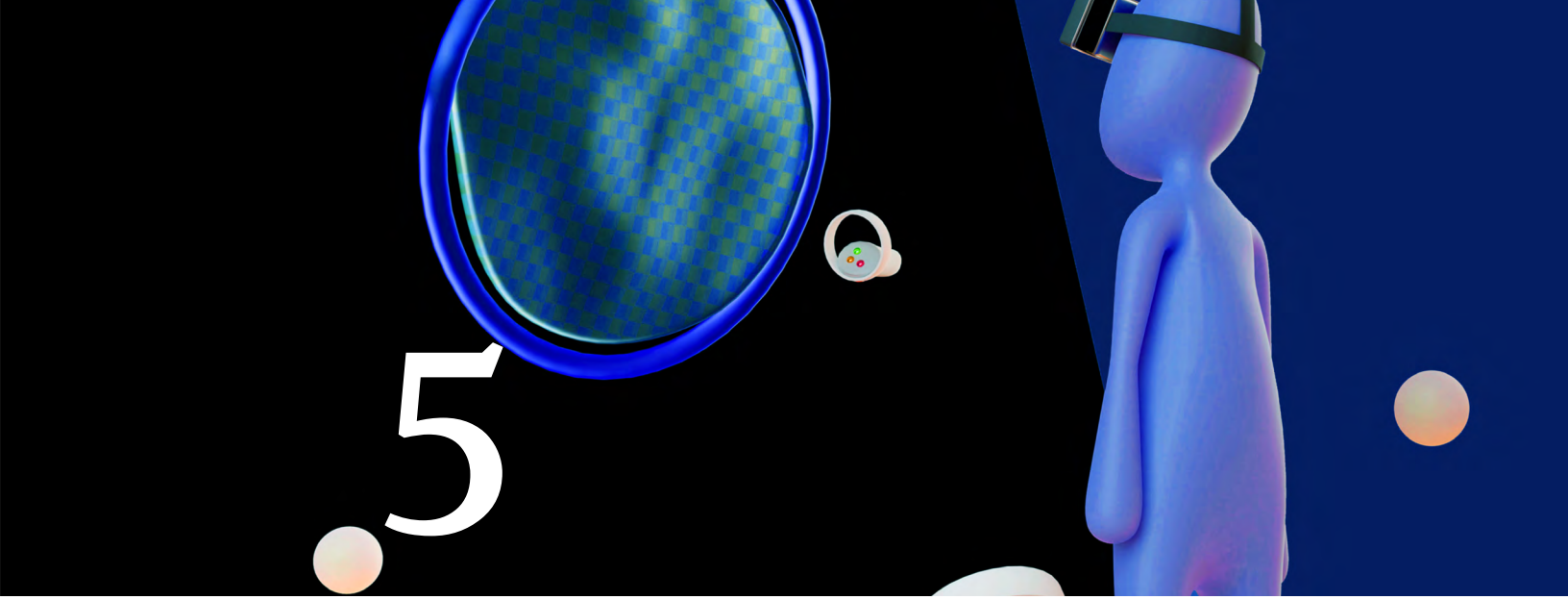
Until the ERP is put into place, however, its benefits are largely theoretical, and their magnitudes cannot be known for certain until they are realized. What reduction in employee time spent on administrative tasks can be achieved? What are the alternative uses to which this time might be applied? What efficiencies can be unlocked via more reliable and speedy supply chain management? And what is the ultimate dollar value to the firm of these various categories, to compare against the software's cost?

These difficulties are compounded when we consider that the firm is not merely selecting between its current solution and a single alternative. Rather, it must consider the full array of alternatives available to it, each carrying its own set of unique costs, risks, and other considerations. Even more, it must weigh the prospect of adopting the best technology currently available against the costs of waiting for a superior alternative to emerge later, as adoption today may preclude a subsequent upgrade due to capital constraints or switching cost-induced lock-in.

In many cases, there is also an important timing mismatch between the costs that must be born to adopt a new technology and the benefits that are ultimately delivered. Many new technologies that promise enhanced productivity require significant upfront expenditures, both directly in the form of purchases of software and equipment, as well as indirectly in the form of time spent training employees and adjusting processes. Their productivity benefits, by contrast, are often realized only diffusely over time. Indeed, in the short-term, many technologies may even negatively impact productivity, owing to an initial period of "technology-specific learning" required before its benefits can be unlocked. This result has been suggested by both theoretical models and empirical research.[10]

Because of the time it takes for many technological investments to justify their costs, a number of technologies that we now recognize as significant breakthroughs were initially considered disappointments. In the early stages of the digital revolution, the massive growth in IT-related expenditures produced little observable effect on productivity, leading economist and Nobel laureate Robert Solow to quip that "we see computers everywhere except in the productivity statistics."[11] This phenomenon became known as the Productivity Paradox. While many IT investments have of course yielded substantial dividends since this time, similar concerns are now being raised about investments in Al and other much-hyped technologies that have yet to make an evident productivity impact commensurate with their costs.[12] It is often difficult to determine whether an underperforming technological investment will eventually bear fruit, or was simply misguided from the outset.

Some of the considerations outlined here—uncertainties around the level of benefits that a given technology will deliver, mismatches in timing between expenditures and gains-can be addressed mathematically by **discounting** values based on their degree of certainty and distance into the future, within the context of a familiar net present value analysis. More sophisticated models are needed, however, to accommodate other decision parameters, such as the option to defer adoption in hopes of adopting a superior alternative in the future.[13]



Strategic Implications

This cost-benefit analysis of technology adoption decisions yields a number of important insights for those looking to bring new technologies to market.

Ideally, a company will want to offer a technology with very high benefits and very low adoption costs. Such a combination is typically not feasible, however, as there are almost always constraints on either the value that can be offered, the direct and indirect costs that can be reduced, or both. To compensate, companies should examine the particular constraints they face, and use every tool available to calibrate those cost and benefit categories over which they do have control.

Three common constraints on new technology strategies, among many possibilities, are:

Three Benefits Offered by New Technologies

1. **High Direct Costs Cannot Be Reduced**	Examples include high hardware manufacturing costs that need to be passed on to the consumer.
2. **Network Effects Limit Value For Early Adopters**	Examples include two-sided platforms whose value to participants on a given side is high only once there is a high number of participants on the other side.
3. **Limit Usage Value Cannot Be Increased**	Examples include products that offer benefits only to a niche customer segment.

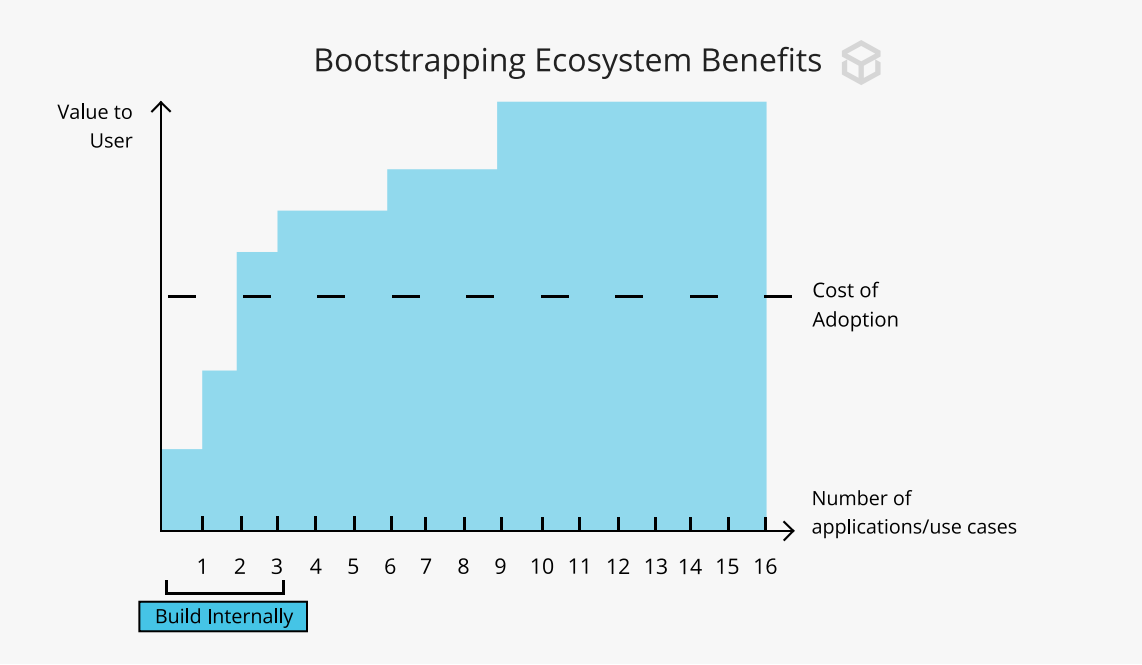
For each of these constraints, a corresponding strategy can be pursued to maximize customer adoption:

Cost/Benefit Constraint	Tactics
High direct costs	Increase value, reduce indirect costs and risks
Network effects limits early benefits	Increase value, reduce upfront direct costs
State of technology limits benefits	Reduce direct and indirect costs, target audience that derives most value

Innovative new technologies that offer significant benefits often emerge only after extensive periods of costly research and development, which must be recouped via high direct costs charged to customers. In these cases of high direct cost constraints, providers should consider methods for increasing the value to users and mitigating the indirect costs and risks of adoption, including:

1. Bundling hardware with multiple in-house applications;
2. Subsidizing ecosystem application development by third-parties;
3. Utilizing interfaces and workflows that users are already familiar with in order to reduce learning curve costs;
4. Implementing data conversion on-ramps to import files and information from the user's previous systems in order to reduce implementation costs; and
5. Providing credible assurances of third-party adoption and ongoing product support to reduce platform risk.

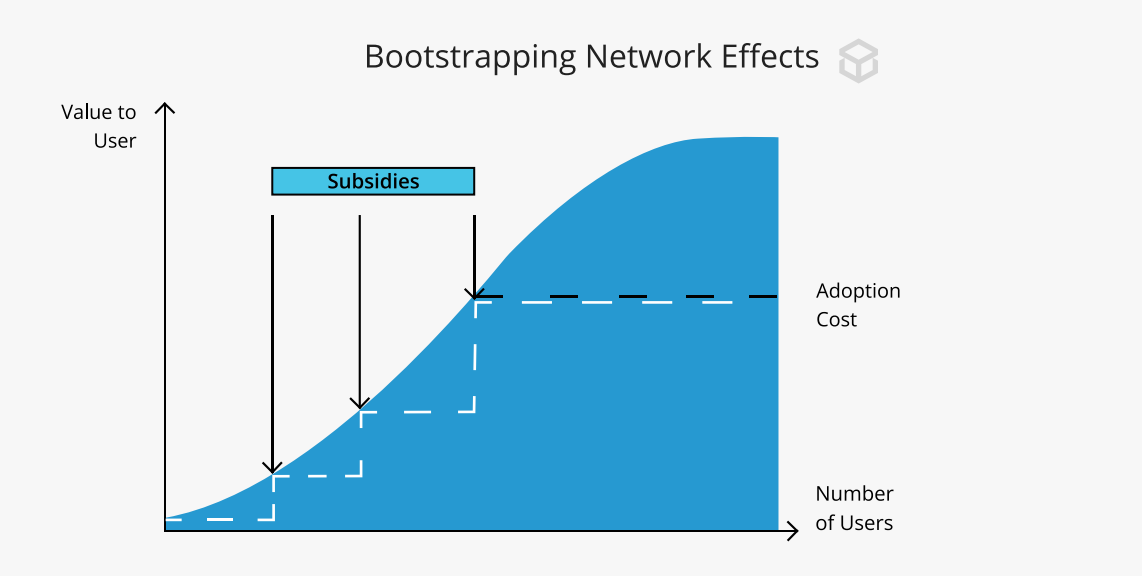
Apple utilized a number of these tactics when launching its first iPhone in 2007. The iPhone came with a number of pre-installed apps developed by Apple including Mail, Calendar, Safari, and Notes. This ensured that users would have a number of built-in ways to interact with the smartphone, and many would get sufficient use from it to justify the $499 price tag. Apple also sought to mitigate the learning curve users faced when interacting with the iPhone's innovative touch screen for the first time by adopting a skeuomorphic design philosophy, meaning that the iPhone's interfaces, icons, and applications resembled their real-world counterparts—for example, the Notes app was designed to look like a yellow legal pad, and the Calculator app resembled a physical calculator. These familiar cues were intended to gently guide users through adoption.[14]



Many products that benefit from network effects are constrained in the amount of value they can deliver to early adopters: because these products increase in value only over time as more users join, there is limited incentive to adopt in the product's early stages. In these cases, providers should consider means to reduce the upfront direct costs that early adopters face, for example, by:

1. Providing targeted subsidies to early adopters;
2. For software offerings, adopting a revenue model that limits the day-one outlays customers need to make.
3. For hardware offerings, providing financing, leasing, and other options that similarly reduce upfront outlays and spread them over time.

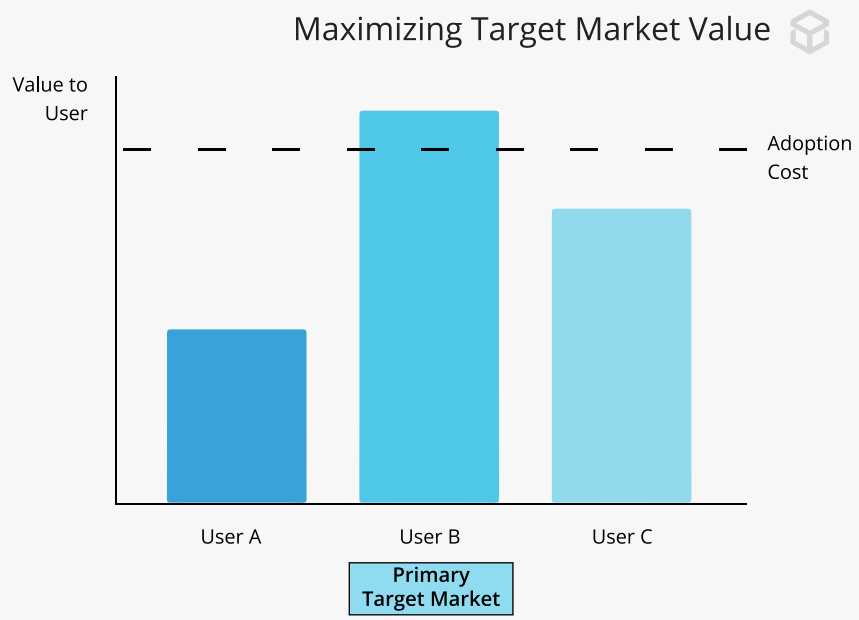
The payment network PayPal adopted the first strategy. PayPal is a two-sided platform that exhibits strong indirect network effects: its value to merchants increases when more users join the network to make payments, and its value to users increases when more merchants join the network to accept payments. Because users had little incentive to join in the network's early days when merchant adoption was low, it provided early adoption rebates and subsidies, at one point giving users a direct $15 rebate for the first $30 they spent. This strategy contributed to PayPal's rapid network growth, which eventually led to its acquisition by eBay for $1.5bn.[15]



Of course, a product that offers very high value to a very wide base of customers is not necessary for success: high adoption can still be achieved with only marginal benefits, or when benefits are limited to only a niche market segment. Some possible tactics for companies constrained in the value they can offer include:

1. Targeting the specific segment of the market most likely to highly value the limited features on offer;
2. Ensuring compatibility with hardware that target customers already use, rather than requiring specialized hardware; and
3. Incorporating guides and tutorials into the user experience to reduce learning curve costs.

Nintendo employed the first tactic when launching its Wii console in 2006, which incorporated motion and gesture sensing technology into its controller. The technology itself was in its infancy, resulting in inaccurate and erratic tracking of the users' gestures, rendering it a less-than-ideal option for hardcore gamers who favor games that require quick reflexes and precise movements. Rather than target these gamers for whom the value of the Wii was relatively low, Nintendo positioned its console as a family- and kid-friendly entertainment system, and packaged it with Wii Sports, a lighter, more playful game accessible to younger audiences.



There are multiple avenues to success for a new technology. While offering high value on day one to a broad audience at low cost may be ideal, it is far from the only possible route to widespread adoption. Careful consideration of the cost-benefit profile of a given product can often yield a successful strategy, even in the face of difficult constraints.

Interested in learning more about the benefits of technological adoption?

Prysm Group is trusted by companies and governments around the globe for information about the economics of emerging technologies. Get new papers and regular updates about our work straight to your inbox with our newsletter—or if you would like to learn more about our consultancy work for organizations—feel free to get in touch using the links below.

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Endnotes

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Email: info@prysmgroup.io
Social: @prysmeconomics
Website: www.prysmgroup.io