Informational Cascades in IT Adoption

Before adopting new systems and procedures, IT managers should ensure they are not unwittingly following the herd.

As unprecedented IT development continues to produce many investment opportunities, imperfectly informed IT managers keep trying to acquire credible external signals to update their knowledge about each new technology. Such learning processes usually help them reach better IT adoption decisions. However, in some cases, independent of their private information, the majority of IT managers quickly come to the same adoption decision. IT managers who want to think dynamically and strategically must understand the causes of herding and its implications for IT adoption and diffusion.

Information economists have suggested that herd behavior may arise because of informational cascades [1–3], which occur when rational individuals ignore their private information and instead mimic the actions of previous decision makers. Basic cascade models have been tested in laboratory experiments. Empirical evidence of informational cascades has been documented in the realms of financial investment, emerging technology adoption, animal mating behavior, and television programming. In the world of IT, such behavior results in adoption herding. In the uncertain business world, IT managers must independently make technology adoption decisions with incomplete information. In many cases, such decisions are difficult to reverse because of significant technology switching costs. These costs could easily exceed the price of the technology itself when technology adopters have such sunk costs as learning, file creation, and the development or purchase of extrinsic complementary systems.

To avoid being locked into an inferior technology, decision makers may wait to let uncertainties be resolved over time. For example, by taking advantage of the option to wait, they can learn about potentially superior alternative technologies [9]. Also, they can obtain more information about the technology and the IT project as a whole by observing the adoption decisions of those who move earlier. So, with asymmetric information, later IT adopters can benefit from information externality—the spillover of nonpublic information from others' adoption decisions. But information cascading and herding behaviors can occur among later adopters as

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well. Although observing previous adopters' decisions facilitates information conveyance, the information revealed through others' actions may overwhelm decision makers' private information and cause them to make adoption decisions independent of their private information. Then their actions become uninformative to others, and information is poorly aggregated thereafter. If many IT adopters blindly follow others based on the same inference, an informational cascade is triggered and everyone may make the same adoption decision in a very short period.

As a simple example of IT adoption cascade, suppose you and other IT managers are considering adopting one of two competing IT platform technologies. One is a potentially winning technology, the other is inferior, but no one knows for sure which one will win. Each person has a private imperfect signal, or judgment about which platform is better, and each signal has a different precision, or accuracy of judgment. We assume that no one knows the others' private signals, and delaying adoption is costly for everyone. Also assume everyone knows that your signal has the greatest precision. (This assumption is not essential but is merely used, as it is in [12], to simplify the argument.) Since the person with the most precise signal gains least by waiting, you will be the first one to make the adoption decision. Once you choose the platform, all others will adopt what you adopt because their signals are less precise than yours. Because other people's imitation actions become uninformative, further delay only incurs costs, and an IT adoption cascade is triggered.

Now compare this scenario with a full information scenario where everyone shares information freely. Supposing your judgment is correct with a probability of 3/4, and the probability that all persons choose the wrong platform is $1-3/4 = 1/4$. Under a full information scenario, the aggregation of everyone's independent signals may significantly reduce this probability. Thus, an IT adoption cascade resulting from incomplete and asymmetric information may trigger a string of incorrect adoption decisions. This problem is exacerbated if there are strong network effects, and in such cases the superior IT platform may not survive.

	Network Externality	*Information Externality*
What is it?	A type of payoff externality, usually positive for technology market. The value of a technology increases as the number of its users increases. The idea behind it is similar to Metcalfe's Law with which many IT professionals are familiar.	Private information revealed by the actions of previous decision makers. Those who make decisions later can take advantage of the information spillover and update their information accordingly.
How does it cause herding in IT adoption?	Via positive network feedback that makes technology with a larger user base more attractive to potential adopters.	It could cause informational cascades that usually generate massive imitation in IT adoption. Most adopters ignore their private information and blindly follow previous adopters' decisions, which might have been incorrect.
What is its relation to informational cascades?	It does not directly cause informational cascades, but positive network effects make informational cascades less fragile and much more difficult to stop.	It is the primary reason why informational cascades sometimes occur when many imperfectly informed IT managers make technology adoption decisions.
What is its effect on IT adoption and diffusion?	It can create "tippy" markets in which one technology gains overwhelming market share in a very short period.	It is an important information conveyance mechanism in IT diffusion, but if information cascades are triggered, suboptimal IT adoption dynamics and IT overbuilding can occur.
What are its business implications for IT adopters?	It provides rich soil for natural technology monopolies. Unless your careful assessment indicates that a less popular technology will bring you more benefits in the long run, select the technology most people adopted.	You might adopt a wait-and-see strategy to reap its benefits, but be cautious about the possibility of informational cascades. Read the signals carefully.
What are its business implications for IT vendors?	The winner-take-all situation it creates makes IT vendors' choice of compatibility level essential. If war between incompatible technologies is justified, make every effort to achieve the critical mass of customer base, and roll the tide against your rivals.	If your IT product is superior but unknown to potential adopters due to asymmetric information, send them credible signals to separate your product from your competitors' products. Influential adopters' early commitment to your technology could motivate others to follow their decisions.

Table 1. Roles of network externality and information externality in IT adoption.

Informational Cascades

Informational cascading is not the only mechanism that causes herding behavior in IT adoption. Another is that many technology markets are subject to positive network feedback that makes the leading technology grow more dominant [4, 6–8]. The dual mechanisms of informational cascading and positive network feedback are mutually reinforcing in many IT markets. Network effects stem from the efficiency of a compatible product user base and the presence of significant technology switching costs. They usually lead to positive payoff externalities that make an IT adopter's return positively correlated with the number of adopters who have already committed themselves to the same technology.[1] In this sense, those network externalities[2] reward herding by increasing the payoffs of those IT adopters who associate themselves with the majority. Although network externalities give IT adopters more incentives to follow the herd, they do not directly cause informational cas-

[1]Network benefits also include extrinsic benefits. Contributors external to a network sometimes provide these benefits to the network. For example, a sizable network usually leads to larger (potentially more competitive) markets for complementary goods or services.

[2]Some people use network effects and network externalities interchangeably. But technically speaking, network externalities are those network effects not internalized through some mechanisms like contracting [6].

IT ADOPTERS MAY FIND THAT FOLLOWING THE MAJORITY IS THE BEST STRATEGY IF THE BENEFITS OF JOINING THE HERD DOMINATE THE BENEFITS OF LEARNING.

cades. Instead they create "tippy" technology markets in which IT adoption processes are more prone to cascades. Positive network feedback also makes informational cascades that have already formed much more difficult to stop. Many information economists claim informational cascades are usually fragile because information is not efficiently aggregated, and a little bit of new information can quickly reverse the tide [2, 3]. However, in technology markets with network externalities, informational cascades are reinforced by later IT adopters who intentionally agglomerate to reap the benefits of network effects. Table 1 compares the roles of network externalities and information externalities in IT adoption.

Information externality gives IT adopters the incentive to learn from previous adopters' decisions. However, when they adopt a wait-and-see strategy, they should be aware of the possibility and the consequences of informational cascades. It is a tough but important task for them to differentiate among informative signals and signals generated through blind imitation. The situation is more challenging when imperfectly informed IT adopters face potential cascades in technology markets with positive network externalities. IT adopters should understand that technology adoption cascades are likely to happen under this scenario, and they may find that following the majority is the best strategy if the benefits of joining the herd dominate the benefits of learning. The presence of network externalities in some technology markets also changes the risk/return ratio of herding. The rationale for each IT adopter to join a herd is simple: network externalities generously reward agglomeration while significantly reducing the possibility of cascade reversals. Unfortunately, such rational herding at an individual level may not be socially desirable. The socially optimal scenario is for everyone to share private information freely to make the adoption decision with the greatest precision. In an informational cascade, significant private information is lost due to uninformative imitations, which reduces overall decision quality and ultimately negatively affects social welfare. IT adopters may end up selecting the inferior technology/standard because some valuable information is lost during the adoption cascade.

Does word-of-mouth learning play an important role?	Yes, the later IT adopters can learn from previous adopters' actions and the outcome of their actions		No, the later IT adopters can only infer nonpublic information from the actions of previous adopters. Cheap talk is not credible.	
Are the payoff externalities positive or negative?	Positive Payoff Externalities (e.g., Positive network externalities)	Negative Payoff Externalities (e.g., An IT adopter's return is lowered by others' adoptions)	Positive Payoff Externalities (e.g., Positive network externalities)	Negative Payoff Externalities (e.g., An IT adopter's return is lowered by others' adoptions)
	Scenario I	**Scenario II**	**Scenario III**	**Scenario IV**
How easy is it to form an IT adoption herd?	Relatively easy. Late adopters make more informed decisions, but network effects reward herding.	Not easy. Late adopters make more-informed decisions, and negative payoff externalities work against herding.	Easy. Massive imitation happens more frequently due to information asymmetry and positive feedback.	Not easy. Negative payoff externalities make herding less desirable.
Once formed, is an informational cascade fragile to external shock?	No. Positive network effects make cascades resilient to new information.	Yes. New information could easily overturn an informational cascade.	No. Positive network effects make cascades resilient to new information.	Yes. New information could easily overturn an informational cascade.
Give a type of IT adoption that fits this scenario.	Adopt relatively mature IT to facilitate cooperation with your partners who have adopted the same technology.	Adopt relatively mature IT to compete with rivals.	Adopt emerging IT, anticipating that others will adopt it later to benefit you.	Adopt an emerging IT to preempt your competitors and take the first mover's advantage.
Common consequence of adoption cascades	Cascades are more likely to lead to the adoption of the right technology.	Cascades are difficult to form.	Cascades occasionally lead to the adoption of the wrong technology.	Cascades could lead to IT overbuilding, but it is usually temporary.

Table 2. Four scenarios of IT adoption.

IT vendors should design their business strategies to allow information externalities and network externalities to work for them, not against them. Since competition among incompatible technologies often results in a winner-take-all situation when network effects are strong, IT vendors' choices of compatibility level become essential. If a standards war among incompatible technologies is justified, they need to make every effort to achieve a critical mass[3] of adopters

[3]Traditional technology diffusion theory suggests that critical mass occurs at the point where the user base of a technology is large enough to self-sustain the technology's future diffusion. Positive network effects make critical mass even more critical in technology competition.

in the early stages of the war [11]. Information asymmetry, from another perspective, also underscores the importance of technology commitments from early (especially influential) adopters. Thanks to information externality, IT vendors can convey more positive information about their products to potential adopters by securing the key technology commitments of early adopters. Both technology diffusion theory and general equilibrium economic analysis suggest that early adopters tend to be opinion leaders who exert a strong influence on followers [10, 12].

Like IT adopters, vendors also need to be cautious about the possibility of informational cascades. For vendors, an informational cascade is clearly a double-edged sword. IT vendors can happily ride the tide if the cascade is in their favor, but they may be swamped if they go against the tide. They are definitely in an uphill battle if positive network effects are also present. However, there are some effective tools to stop or even reverse the tide if vendors believe their technology is superior when its superiority is unknown to potential adopters due to information asymmetry. In the early stages of a cascade, they can send potential adopters credible signals to separate their products from those of their competitors and to convince adopters that following uninformative herd behavior is inefficient. Some examples of this signaling strategy include advertising campaigns, strategic alliances, and various pricing strategies and product pre-announcements. How to use costly signals to reach separating equilibria has long been discussed in the information economics and marketing literature. Under certain circumstances, ordinary informal conversation (cheap talk) may also achieve the same goal.

Word of Mouth

Until now, our discussion assumes that later IT adopters can only infer nonpublic information from the actions of previous adopters. This assumption, often used in informational cascade research, implicitly suggests that later adopters cannot learn more information from previous adopters' experience through conversation or other social learning, mechanisms. It is consistent with the belief that information obtained through subjective learning, like conversation, usually lacks credibility, and actions speak louder than words. However, both innovation diffusion research and recent information economics research suggest that word-of-mouth learning can significantly affect technology diffusion processes [5, 10]. The conversational learning among these IT adopters can be greatly facilitated by the Internet and other telecommunication networks. (But the Internet may not necessarily reduce the problems of informational cascades; see [3].) Intuitively, inefficient informational cascades, or those leading to the wrong IT platform choices, are less likely to occur when additional information revelation channels exist. Even if an inefficient cascade occurs, it is more likely to be overturned by later adopters who observe the payoffs of previous adopters and gain private information through conversation. Unfortunately, learning by observing previous adopters' payoffs is difficult under many IT adoption circumstances. Precise quantification of IT investment payoffs is notoriously complicated, and the outcomes of many IT adoption projects can be judged only in the long run, while the competitive business environment usually forces managers to make IT adoption decisions in relatively short time frames.

Conversational learning is relatively common in IT adoption, but is such talk credible? Later IT adopters definitely benefit from their conversations with those who have made the adoption, but before taking these early birds' words seriously they should always ask themselves: Is it in the early adopters' best interests to tell me the truth? In a cooperative environment, such as a project development team, people are more than willing to share their IT adoption information and experience. However, managers in most cases face an uncooperative (competitive) environment when they make their IT adoption decisions. To facilitate our discussion of such cases, we describe four IT adoption scenarios in Table 2. We use the credibility of conversation and the sign of payoff externalities as two criteria for classification. Conversational learning plays an important role in scenarios I and II, but its role is downplayed in scenarios III and IV. The technology markets in scenarios I and III exhibit positive payoff externalities, such as network externalities, and the markets in scenarios II and IV exhibit negative payoff externalities, such as pecuniary externalities.

Negative payoff externalities are common in many competitive business environments where a company's return from adopting a technology decreases as more companies adopt the same technology. They usually arise because of downward sloping demand curves, and they punish IT adoption herding and make informational cascades less likely. The recent fiber cable network glut in the U.S. and Europe exemplifies the potential damage caused by negative payoff externalities. Driven by skyrocketing demand for network bandwidth and global connectivity, Qwest, Global Crossing, WorldCom, Williams Communications, and many others raced to build their nationwide backbone fiber optic networks during the late 1990s. This investment herding quickly led to global fiber network overbuilding that eventually resulted in a gigantic supply and demand mismatch. These companies paid a hefty price to learn that herding could be extremely harmful when strong negative payoff externalities exist.

As discussed earlier, network externalities make informational cascades difficult to overturn. Negative payoff externalities do just the opposite; by raising the price tag for blind imitation they can significantly increase the fragility of informational cascades. Table 2 also gives a type of IT adoption that likely fits each scenario. Worth noting is that potential adopters of emerging IT are less likely to learn from others' experience simply because no one has much experience with a new technology; technology vendors might be exceptions, but their opinions are clearly biased. Conversational learning is much more helpful for potential adopters of relatively mature IT, as prior experience is abundant. IT adoption cascades arising under different scenarios also lead to different business implications. Network effects make the IT diffusion process prone to cascades that may occasionally lead to incorrect technology selection. However, if adopters convey nonpublic information through multiple channels, including conversation, they are more likely to adopt the correct technology in an adoption cascade. On the other hand, negative payoff externalities make potential IT adopters reluctant to follow a herd. Even if they imitate others' adoption decisions, the resulting adoption cascade is often fragile because negative payoff externalities will sooner or later manifest themselves.

Conclusion

Although herd behavior is commonly exhibited and observed in IT adoption, IT managers do not have a systematic framework to fully understand its implications. Recent developments in information economics suggest that informational cascades may be one important force behind IT adoption herding. As various degrees of information asymmetry exist in most IT adoption processes, informational cascades may profoundly change the dynamics of IT competition and diffusion. Informational cascades are enabled by information externalities but reinforced by network externalities. Faced with adoption cascades, potential IT adopters should differentiate informative signals from the ones generated by blind imitation. IT vendors need to make every effort to ignite favorable adoption cascades when network effects are strong. If an IT vendor with a superior product falls victim to adoption cascades, it can send potential adopters credible signals to convey positive information about its product.

Besides direct observation of other adopters' actions, other communication channels, like conversation, can convey useful information under some IT adoption scenarios. Such channels, combined with negative payoff externalities, might mitigate the propensity toward IT adoption cascades. Although we discuss IT adoption cascades under four scenarios, we should point out that many real-world IT adoption situations are hybrids. Many IT investments involve both positive network externalities and negative payoff externalities. For example, a compatible technology user base may enhance each adopter's welfare, but downstream market competition may negatively affect each adopter's payoff. With a better understanding of the forces behind adoption cascades, IT managers should feel more comfortable when dealing with complex IT adoption situations under competitive pressure and information asymmetries. C

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