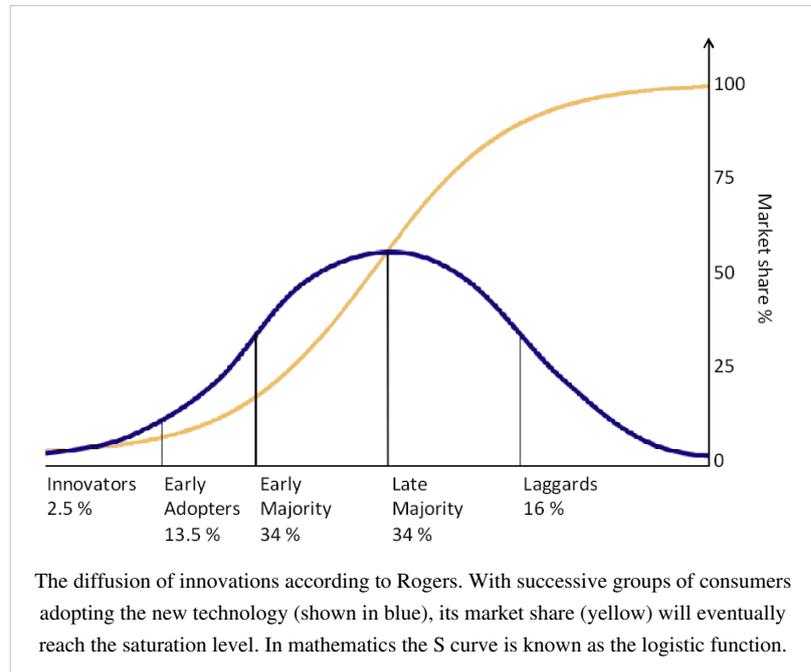


# Diffusion of innovations

**Diffusion of Innovations** is a theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures. The concept was first studied by the French sociologist Gabriel Tarde (1890) and by German and Austrian anthropologists such as Friedrich Ratzel and Leo Frobenius.<sup>[1]</sup> Its basic epidemiological or internal-influence form was formulated by H. Earl Pemberton,<sup>[2]</sup> who provided examples of institutional diffusion such as postage stamps and compulsory school laws.



## History

In 1962 Everett Rogers, a professor of rural sociology published *Diffusion of Innovations*. In the book, Rogers synthesized research from over 508 diffusion studies and produced a theory for the adoption of innovations among individuals and organizations.

The book proposed 4 main elements that influence the spread of a new idea: the innovation, communication channels, time, and a social system. That is, diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Individuals progress through 5 stages: knowledge, persuasion, decision, implementation, and confirmation. If the innovation is adopted, it spreads via various communication channels. During communication, the idea is rarely evaluated from a scientific standpoint; rather, subjective perceptions of the innovation influence diffusion. The process occurs over time. Finally, social systems determine diffusion, norms on diffusion, roles of opinion leaders and change agents, types of innovation decisions, and innovation consequences. To use Rogers' model in health requires us to assume that the innovation in classical diffusion theory is equivalent to scientific research findings in the context of practice, an assumption that has not been rigorously tested.<sup>[3]</sup>

The origins of the diffusion of innovations theory are varied and span across multiple disciplines. Rogers identifies six main traditions that impacted diffusion research: anthropology, early sociology, rural sociology, education, industrial, and medical sociology. The diffusion of innovation theory has been largely influenced by the work of rural sociologists.<sup>[4]</sup>

## Elements

The key elements in diffusion research are:

Element	Definition
Innovation	Rogers defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption". <sup>[5]</sup>
Communication channels	A communication channel is "the means by which messages get from one individual to another". <sup>[6]</sup>
Time	"The innovation-decision period is the length of time required to pass through the innovation-decision process". <sup>[7]</sup> "Rate of adoption is the relative speed with which an innovation is adopted by members of a social system". <sup>[8]</sup>
Social system	"A social system is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal". <sup>[9]</sup>

## Decisions

Two factors determine what type a particular decision is :

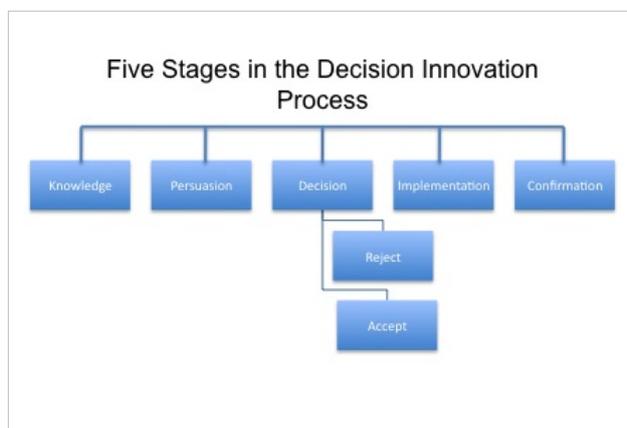
- Whether the decision is made freely and implemented voluntarily,
- Who makes the decision.

Based on these considerations, three types of innovation-decisions have been identified within diffusion of innovations.

Type	Definition
Optional Innovation-Decision	This decision is made by an individual who is in some way distinguished from others in a social system.
Collective Innovation-Decision	This decision is made collectively by all individuals of a social system.
Authority Innovation-Decision	This decision is made for the entire social system by few individuals in positions of influence or power.

## Mechanism

Diffusion of an innovation occurs through a five–step process. This process is a type of decision-making. It occurs through a series of communication channels over a period of time among the members of a similar social system. Ryan and Gross first indicated the identification of adoption as a process in 1943 (Rogers 1962, p. 79). Rogers categorizes the five stages (steps) as: awareness, interest, evaluation, trial, and adoption. An individual might reject an innovation at any time during or after the adoption process. In later editions of the Diffusion of Innovations Rogers changes the terminology of the five stages to: knowledge, persuasion, decision, implementation, and confirmation. However the descriptions of the categories have remained similar throughout the editions.



### Five stages of the adoption process

Stage	Definition
Knowledge	In this stage the individual is first exposed to an innovation but lacks information about the innovation. During this stage of the process the individual has not been inspired to find more information about the innovation.
Persuasion	In this stage the individual is interested in the innovation and actively seeks information/detail about the innovation.
Decision	In this stage the individual takes the concept of the innovation and weighs the advantages/disadvantages of using the innovation and decides whether to adopt or reject the innovation. Due to the individualistic nature of this stage Rogers notes that it is the most difficult stage to acquire empirical evidence (Rogers 1964, p. 83).
Implementation	In this stage the individual employs the innovation to a varying degree depending on the situation. During this stage the individual determines the usefulness of the innovation and may search for further information about it.
Confirmation	Although the name of this stage may be misleading, in this stage the individual finalizes his/her decision to continue using the innovation and may use the innovation to its fullest potential.

### Rates of adoption

The rate of adoption is defined as: the relative speed with which members of a social system adopt an innovation. It is usually measured by the length of time required for a certain percentage of the members of a social system to adopt an innovation (Rogers 1962, p. 134). The rates of adoption for innovations are determined by an individual's adopter category. In general individuals who first adopt an innovation require a shorter adoption period (adoption process) than late adopters.

Within the rate of adoption there is a point at which an innovation reaches critical mass. This is a point in time within the adoption curve that enough individuals have adopted an innovation in order that the continued adoption of the innovation is self-sustaining. In describing how an innovation reaches critical mass, Rogers outlines several strategies in order to help an innovation reach this stage. These strategies are: have an innovation adopted by a highly respected individual within a social network, creating an instinctive desire for a specific innovation. Inject an innovation into a group of individuals who would readily use an innovation, and provide positive reactions and benefits for early adopters of an innovation.

### Rogers' 5 Factors

Rogers defines several intrinsic characteristics of innovations that influence an individual's decision to adopt or reject an innovation.

Factor	Definition
Relative Advantage	How improved an innovation is over the previous generation.
Compatibility	The level of compatibility that an innovation has to be assimilated into an individual's life.
Complexity or Simplicity	If the innovation is too difficult to use an individual will not likely adopt it.
Trialability	How easily an innovation may be experimented with as it is being adopted. If a user has a hard time using and trying an innovation this individual will be less likely to adopt it.
Observability	The extent that an innovation is visible to others. An innovation that is more visible will drive communication among the individual's peers and personal networks and will in turn create more positive or negative reactions.

## Adopter categories

Rogers defines an adopter category as a classification of individuals within a social system on the basis of innovativeness. In the book *Diffusion of Innovations*, Rogers suggests a total of five categories of adopters in order to standardize the usage of adopter categories in diffusion research. The adoption of an innovation follows an S curve when plotted over a length of time.<sup>[10]</sup> The categories of adopters are: innovators, early adopters, early majority, late majority, and laggards (Rogers 1962, p. 150)

Adopter category	Definition
Innovators	Innovators are the first individuals to adopt an innovation. Innovators are willing to take risks, youngest in age, have the highest social class, have great financial lucidity, very social and have closest contact to scientific sources and interaction with other innovators. Risk tolerance has them adopting technologies which may ultimately fail. Financial resources help absorb these failures. (Rogers 1962 5th ed, p. 282)
Early Adopters	This is the second fastest category of individuals who adopt an innovation. These individuals have the highest degree of opinion leadership among the other adopter categories. Early adopters are typically younger in age, have a higher social status, have more financial lucidity, advanced education, and are more socially forward than late adopters. More discrete in adoption choices than innovators. Realize judicious choice of adoption will help them maintain central communication position (Rogers 1962 5th ed, p. 283).
Early Majority	Individuals in this category adopt an innovation after a varying degree of time. This time of adoption is significantly longer than the innovators and early adopters. Early Majority tend to be slower in the adoption process, have above average social status, contact with early adopters, and seldom hold positions of opinion leadership in a system (Rogers 1962 5th ed, p. 283)
Late Majority	Individuals in this category will adopt an innovation after the average member of the society. These individuals approach an innovation with a high degree of skepticism and after the majority of society has adopted the innovation. Late Majority are typically skeptical about an innovation, have below average social status, very little financial lucidity, in contact with others in late majority and early majority, very little opinion leadership.
Laggards	Individuals in this category are the last to adopt an innovation. Unlike some of the previous categories, individuals in this category show little to no opinion leadership. These individuals typically have an aversion to change-agents and tend to be advanced in age. Laggards typically tend to be focused on "traditions", likely to have lowest social status, lowest financial fluidity, be oldest of all other adopters, in contact with only family and close friends, very little to no opinion leadership.

## Heterophily and communication channels

Lazarsfeld and Merton first called attention to the principles of homophily and its opposite, heterophily.<sup>[11]</sup> Using their definition, Rogers defines homophily as "the degree to which pairs of individuals who interact are similar in certain attributes, such as beliefs, education, social status, and the like".<sup>[11]</sup> When given the choice, individuals usually choose to interact with someone similar to him or herself.<sup>[12]</sup> Furthermore, homophilous individuals engage in more effective communication because their similarities lead to greater knowledge gain as well as attitude or behavior change.<sup>[12]</sup> However, most participants in the diffusion of innovations are heterophilous, meaning they speak different languages, so to speak.<sup>[12]</sup> The problem is that diffusion requires a certain degree of heterophily; if two individuals are identical, no diffusion occurs because no new information can be exchanged.<sup>[12]</sup> Therefore, an ideal situation would involve two individuals who are homophilous in every way, except in knowledge of the innovation.<sup>[12]</sup>

## Opinion leaders within a social system

Throughout the diffusion process there is evidence that not all individuals exert an equal amount of influence over all individuals. In this sense there are Opinion Leaders, leaders who are influential in spreading either positive or negative information about an innovation. Rogers relies on the ideas of Katz & Lazarsfeld and the two-step flow theory in developing his ideas on the influence of Opinion Leaders in the diffusion process<sup>[13]</sup> Opinion Leaders have the most influence during the evaluation stage of the innovation-decision process and late adopters (Rogers 1964,

p. 219). In addition opinion leaders have a set of characteristics that set them apart from their followers and other individuals. Opinion Leaders typically have greater exposure to the mass media, more cosmopolitan, greater contact with change agents, more social experience and exposure, higher socioeconomic status, and are more innovative.

## Organizations

Innovations are often adopted by organizations through two types of innovation-decisions: collective innovation decisions and authority innovation decisions. The collection-innovation decision occurs when the adoption of an innovation has been made by a consensus among the members of an organization. The authority-innovation decision occurs when the adoption of an innovation has been made by very few individuals with high positions of power within an organization (Rogers 2005, p. 403). Unlike the optional innovation decision process, these innovation-decision processes only occur within an organization or hierarchical group. Within the innovation decision process in an organization there are certain individuals termed "champions" who stand behind an innovation and break through any opposition that the innovation may have caused. The champion within the diffusion of innovation theory plays a very similar role as to the champion used within the efficiency business model Six Sigma. The innovation process within an organization contains five stages that are slightly similar to the innovation-decision process that individuals undertake. These stages are: agenda-setting, matching, redefining/restructuring, clarifying, routinizing.

## Consequences of adoption

There are both positive and negative outcomes when an individual or organization chooses to adopt a particular innovation. Rogers states that this is an area that needs further research because of the biased positive attitude that is associated with the adoption of a new innovation (Rogers 2005, p. 470). In the Diffusion of Innovation, Rogers lists three categories for consequences: desirable vs. undesirable, direct vs. indirect, and anticipated vs. unanticipated.

In her article, "Integrating Models of Diffusion of Innovations," Barbara Wejnert details two categories for consequences: public vs. private and benefits vs. costs.

### Public vs. Private

Public consequences refer to the impact of an innovation on those other than the actor, while private consequences refer to the impact on the actor itself.<sup>[14]</sup> Public consequences usually involve collective actors, such as countries, states, organizations, or social movements.<sup>[14]</sup> The results are usually concerned with issues of societal well-being.<sup>[14]</sup> Private consequences usually involve individuals or small collective entities, such as a community.<sup>[14]</sup> The innovations are usually concerned with the improvement of quality of life or the reform of organizational or social structures.<sup>[14]</sup>

### Benefits vs. Costs

The benefits of an innovation obviously refer to the positive consequences, while the costs refer to the negative.<sup>[15]</sup> Costs may be monetary or nonmonetary, direct or indirect.<sup>[15]</sup> Direct costs are usually related to financial uncertainty and the economic state of the actor.<sup>[15]</sup> Indirect costs are more difficult to identify.<sup>[15]</sup> An example would be the need to buy a new kind of fertilizer to use innovative seeds.<sup>[15]</sup> Indirect costs may also be social, such as social conflict caused by innovation<sup>[15]</sup>

## Mathematical treatment

The diffusion of an innovation often follows a logistic function or S curve.

## International Institute for Applied Systems Analysis (IIASA)

Several papers on the relationship between technology and the economy were written by researchers at the International Institute for Applied Systems Analysis (IIASA). The pertinent papers deal with energy substitution and the role of work in the economy as well as with the long economic cycle. Using the logistic function, these researchers were able to provide new insight into market penetration, saturation and forecasting the diffusion of various innovations, infrastructures and energy source substitutions.<sup>[16]</sup> Cesare Marchetti published on Kondratiev waves and on diffusion of innovations.<sup>[17]</sup>

A mathematical discussion of diffusion and substitution models can be found in th Grübler (1990).<sup>[18]</sup>

## Diffusion data

Diffusion curves for radio, television, VCR, cable, flush toilets, clothes washer, refrigerator, home ownership, air conditioning, dishwasher, electrified households, telephone, cordless phones, cellular phone, per capita airline miles, personal computers, internet are available from link on footnote.<sup>[19]</sup>

Diffusion curves for infrastructures (canals, railroads, highways, pipelines, airlines) are available from a link on the footnote.<sup>[18]</sup>

## Criticism

Much of the evidence for the diffusion of innovations gathered by Rogers comes from agricultural methods and medical practice.

Various computer models have been developed in order to simulate the diffusion of innovations. Veneris<sup>[20]</sup> [21] developed a systems dynamics computer model which takes into account various diffusion patterns modeled via differential equations.

There are a number of criticisms of the model which make it less than useful for managers. First, technologies are not static. There is continual innovation in order to attract new adopters all along the S-curve. The S-curve does not just 'happen'. Instead, the s-curve can be seen as being made up of a series of 'bell curves' of different sections of a population adopting different versions of a generic innovation.

Rogers has placed the contributions and criticisms of diffusion research into four categories: pro-innovation bias, individual-blame bias, recall problem, and issues of equality.<sup>[22]</sup>

## Electronic communication social networks

Prior to the introduction of the Internet, it was argued that social networks had a crucial role in the diffusion of innovation particularly Tacit knowledge in the book *The IRG Solution - hierarchical incompetence and how to overcome it*. The book argued that the widespread adoption of computer networks of individuals would lead to the much better diffusion of innovations, and with greater understanding of their possible shortcomings, and the identification of needed innovations that would not have otherwise occurred - the Relevance paradox.

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### Notations

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### Notes

- [1] see the article on Trans-cultural diffusion or Roland Burrage Dixon (1928): *The Building of Cultures*.
- [2] Pemberton, H. E. (1936) 'The Curve of Culture Diffusion Rate', *American Sociological Review*, 1 (4): 547-556.
- [3] "A Guide to Knowledge Translation Theory" (<http://www.hpme.utoronto.ca/Assets/hpme/events/hsr07/davis3.pdf>)
- [4] Ryan (1943), see above.
- [5] (Rogers, 1983. p. 11)
- [6] (Rogers, 1983. p. 17)
- [7] (Rogers 1983, p. 21)
- [8] (Rogers, 1983. p. 21, 23)
- [9] (Rogers, 1983. p. 24)
- [10] J. C. Fisher and R. H. Pry , "A Simple Substitution Model of Technological Change", *Technological Forecasting & Social Change*, vol. 3, no. 1 (1971)
- [11] (Rogers, 1983. p. 18)
- [12] (Rogers, 1983. p. 19)
- [13] Katz, Elihu & Lazarsfeld, Paul (1955). *Personal influence: The part played by people in the flow of mass communications*, Glencoe: Free Press
- [14] (Wejnert, "Integrating Models of Diffusion of Innovations," p. 299)
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- [22] Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York, NY: Free Press.
- [23] <http://books.google.com/?id=zw0-AAAAIAAJ>

### External links

- The Diffusion Simulation Game (<https://www.indiana.edu/~simed/istdemo/index.html>), about adopting an innovation in education
- The Pencil Metaphor on diffusion of innovation particularly ICT in education (<http://www.teachers.ash.org.au/lindy/pencil/pencil.htm>)

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