IDEESE Module 1.3a
Transnational Diffusion of Ideas and Practices

MJ Peterson

Version 1; August 2008

Learning Objectives

Students will be able to

1. Understand a basic model of diffusion of ideas

2. Understand how national differences affect diffusion

Outline for In-class Discussion

I. Basic model of diffusion of ideas (the S-curve)
[*Many science and engineering students will be familiar with S-curves and hazard models; if everyone in the group is familiar this segment of class can proceed quickly.]*

A. Outline the basic features of the model.

1. Exposure infection mechanism of disease vs. learning consideration-choice mechanism for ideas and technology.

2. Three phases of diffusion: slowly rising use initially; exponential increase in use during middle phase; return to slow increase as population is "saturated" by the idea or technology.

3. Range of choice: be sure students understand the distinctions among inventors and innovators; the early adopter-late adopter-nonadopter distinctions are more obvious. Be sure to emphasize that in this analytical scheme "nonadopter" denotes persons who have made an informed choice not to use the technology. Persons whose non-use stems from unawareness could be called "uninformed non-users" or some such thing.

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B. Highlight the material and social factors that affect individuals' choices, and ask students whether they can think of examples.

1. Physical and cost characteristics of the technology itself or in comparison to competing technologies;

2. Economic benefit/cost ratio of using the new technology;

3. Mode of social decision about adopting new technologies;

4. Communication channels used to promote the new technology;

5. Social and material conditions in which the technology will be used;

6. Extent of promotion by trusted persons;

II. How national differences affect diffusion and use

A. Remind students that this can be analyzed by thinking about the six categories of factors that affect reception of new ideas and technologies within a country.

B. Encourage students to think of examples of technologies that are used differently in various countries. Have them talk about which factor or factors seem to be at the root of the differences.

Suggested Case Studies

International Dimensions of Ethics Education in Science and Engineering Case Study Series will develop an appropriate case in 2008/2009.

Recommended Readings

For assignment prior to class discussion

1.) Transnational Diffusion of Ideas and Technologies (Included in this module)

2.) Excerpt from George Basalla, *The Evolution of Technology* (1988)

Resources Included with this Module

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Chart for Discussion of National Differences in Technology Use

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Factor	Country 1	Country 2	Country 3
characteristics of the technology			
economic benefit/ cost ratio of use			
mode of social decision			
communication channels available			
social and material conditions surrounding use			
extent of promotion by trusted persons			

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Appropriate Technology

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The appropriate technology movement emerged in the early 1970s from two related critiques of the large-scale industrial technology used in both the capitalist West and the communist East, one focused on conditions in the industrial states and the other focused on the impact of exporting technologies used in industrial countries to the developing countries of Africa, Asia, the Middle East, and Latin America. The bases of critique applied to industrial countries were that large-scale technologies promoted over-exploitation of natural resources, over-centralization, concentration of political and economic power, less employment because high technology substitute machines for workers, and deskilling of workers because more of the work process is embodied in the movements of the machine rather than in the actions of the operator. The bases of critique applied in developing countries were that industrial state technologies, developed as they were in capital-rich and relatively labor-short economies, failed to fit the capital-poor and labor-abundant factor endowments of developing country economies, that they were too expensive for the country in general and especially for the poor, that they were seldom culturally appropriate, and that their operation assumed availability of infrastructure and levels of general understanding about how technologies work that were absent locally. In sum, the argument is that technology has been developed too far and now dominates humanity rather than serving humanity.

The founder of the appropriate technology movement, E. F. Schumacher, argued that technology should be designed in ways that would promote health, beauty, and permanence. Technology should not be regarded only as a means to an immediate end, it must be evaluated in terms of its contribution to a process of production or activity beneficial not only to its immediate users, but also to the society at large.[1] He faulted out conventional economic thinking in both West and East for failing to consider the most appropriate scale for an activity and condemned notions that "growth is good", and that "bigger is better." He questioned the appropriateness of using the typically capital-intensive methods of mass production in developing countries; he argued instead for what he called "production by the masses," that is, use of or labor-intensive methods. Schumacher was one of the first economists to question the appropriateness of using GNP to measure human wellbeing, emphasizing that "the aim ought to be to obtain the maximum amount of well being with the minimum amount of consumption." Thus he regarded a single-minded concentration on output and technology as dehumanizing. In his view work places should first be dignified and meaningful. Efficiency is still important but must be defined by the propositions that nature is priceless,

[1] E. F. Schumacher, when *Small is Beautiful: Economics as if People Mattered* (New York: Harper and Row, 1973).

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and that depletable resources should be treated as capital assets to be carefully husbanded over time rather than as income accruing anew every year.

It is not surprising that the appropriate technology movement took off in the wake of the 1973 oil crisis, which highlighted the centrality of inexpensive fuel to the development and maintenance of post-World War II prosperity, and cast doubt on the likely success of continuing along the paths of economic development followed since the start of the industrial revolution. The appropriate technology critique also fit well with the broader "counterculture" discontent with modernity that had been spreading since the late 1960s. The phrase "high technology" began to lose its luster, becoming identified in many minds with excessive mechanization, displacement of human labor by machines, wasteful depletion of resources, and increased pollution. While the later computer revolution restored luster to the phrase "high technology" (especially in its shorter "hi-tech" form), resistance to capital-intensive and centralizing technologies persisted.

Though Schumacher insisted on the importance of ecological sustainability, most advocates of appropriate technology focused primarily on the needs of developing countries in the 1970s and early 1980s. As the environmental movement gained strength later in the decade, however, the concern about the environmental implications of technology increased. That element was incorporated into both the industrial and developing country visions of the appropriate technology movement.

In the words of some current advocates:

> "[Appropriate technology] is suitable for the circumstances or purposes for which it is designed, and it is sustainable - meaning it is capable of being maintained at a steady level without exhausting natural resources or causing severe ecological damage, forever.
>
> It is the sort of technology that is right for small-scale, grassroots, people-centered economics. Appropriate technology is about being mindful of our actions and the consequences of those actions. It is the foundation of sustainable living and therefore works from the bottom up to meet grassroots economic needs, not from the top down. Fundamentally, appropriate technology is about caring, helping and appreciating and forward-thinking. It is as much a philosophy, a way of seeing things, as it is a technology.
>
> Because appropriate technology is firstly a grassroots technology it is expressed in an extensive array of inventive, creative solutions to problems, that 'outsiders' would be unlikely to consider. The very diversity of appropriate technology means that it changes with each situation - there is infinite variety in real life situations where appropriate technology is used and it must fit each of these situations. Whereas non-appropriate technology often forces life to fit the technology."[2]

[2] www.ustechnologysolutions.com

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Advocates of appropriate technology have been very enthusiastic about renewable energy not only for its environmental benefits but also because it will allow households, firms, and communities to disconnect from the massive power grids that now crisscross the industrial world and make people dependent on capital-intensive infrastructure operated by governments or by large monopoly firms. They have also been enthusiastic about compressed earth block (CEB), a building material made by mixing the right proportions of dirt, clay, small stones, and a small amount of water, putting the mix into a mechanical press, and forming it into a block. CEB blocks have a number of advantages over other building materials: in humid areas they can be formed without adding water, and the small amount used in dry areas also means drying time is less than needed for other forms of block or brick, suitable soil is often very close to the building site so saves on shipping costs, a single mechanical press can produce anywhere from 800 to 5000 blocks of the day (5000 being enough to build a 1200-square foot house), the press gives the blocks a uniform size, truly flat sides, and 90° angle edges allowing easier building, and the external appearance is similar to that of stucco houses, the "mortar" used to connect the bricks is simply the same dirt-clay-water mix used to make them. Construction with CEB is simple enough that unskilled labor can perform most of the work. They are made from natural materials that do not include any toxic chemicals and therefore produce no out-gassing. The resulting walls are fire resistant, sound resistant, insect resistant, and mold resistant because they are dense and do not include any paper materials.[3]

Appropriate technology is often described as “simple,” but it is a mistake to assume that the most appropriate technology is the simplest tools or machines capable of doing a particular job. They may not actually meet the criteria qualifying a technology as “appropriate” in a particular situation. Two sets of criteria guide selection: ecological sustainability, and social equity. Ecological sustainability means selecting those technologies that will do a particular job or permit a particular activity with the least amount of pollution, waste, or harm to the surrounding environment. Social equity means selecting technologies that can be acquired, operated, and maintained locally at levels of cost affordable to local users, whether those users are rural and small-town dwellers in industrial countries or the poorest members of the rural and urban populations in developing countries. In most situations, several technologies or devices meet the criteria. Thus, a concern with appropriate technology does not by itself determine the selection of the tool for a particular job. Rather, it provides a set of guidelines for choice that identify some possible choices as undesirable and others as desirable, and encourages selection among those identified as desirable.

Advocates of appropriate technology have sometimes caused confusion, even for themselves, by using several overlapping terms to describe the desirable sorts of technology. The process began with Schumacher himself, who introduced the term "intermediate technology" to describe technology that is more effective though more expensive than the technologies prevailing earlier in developing countries, but at least an order of magnitude (10x) less costly than the technologies used in industrial countries. Though

[3] See producer websites at www.beyondadobe.com or www.earthblockinc.com

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more expensive than the less effective traditional technologies, with a lower cost, does make intermediate technologies available to small businesses and village groups. The term "blended technology" has been used to describe an appropriate technology that has been modified in some ways to accommodate cultural differences among users. The term "soft technology," also first used in the 1970s, acquired two meanings. The first was developed by Amory Lovins[4] in his phrase "soft energy paths," with which he contrasted renewable energy sources, such as windmills or solar cells, to the "hard paths" of fossil fuels or nuclear reactors commonly used in the industrial economies. The second usage or a first two sets of rules, guidelines, or outlines of the steps involved in some activity that exist inside human brains rather than being embodied in a physical device or even a computer software program. These are also technologies in the sense that they permit accomplishing some activity, but they are very different than the fabricated devices we usually associate with the word "technology".
"Appropriate technology" can be described as "low impact technology," but its development often rests on highly advanced scientific and engineering research. The windmills distributed by appropriate technology providers today are much more efficient than the windmills distributed in the 1980s because they incorporate the considerable learning about turbine design, mechanisms for steering the blades to catch wind most effectively, materials, and windmill placement that has occurred over subsequent years. New research findings about the way water carries cholera germs inspired development of a new type of cloth filter that villagers in cholera infested areas can use to purify their water supply.

The promises of low cost, easy maintenance, small scale, and low environmental impact make appropriate technologies highly attractive to many users in both industrial and developing countries. A large number of nongovernmental organizations, foundations, government agencies, and intergovernmental organizations have supported the diffusion of particularly simple or intermediate technologies around the world.

With any technology, attention must be given to the physical and social conditions under which the technology will be used. Suppose the problem at hand is improving the water supply for a remote village. Technology choosers must first consider the character of the available sources of water. If groundwater is located only at a large depth say 50m below the surface, the village will need a mechanically drilled well and a submersible electric pump. If groundwater is located between 10 and 50m below the surface it will be possible to dig the well manually, but an electric pump will still be needed to bring the water to the surface. If groundwater is within 10m of the surface, then it is possible to use hand pumps or foot treadle pumps because they can operate without electricity and are mechanically simpler. Some models of hand pumps have to be used regularly and maintained carefully or they will fail. However, their mechanical simplicity means they can be repaired locally. Surface water is available in some areas, but may need treatment before it is safe to drink or be used for irrigation. Engineers have developed a number of relatively small-scale water treatment systems being used extensively in South and Southeast Asia. Locally-operated “water refill stations,” sometimes known as “water treatment kiosks,” employ sophisticated

[4] Amory B. Lovins, Energy Paths: Toward a Durable Piece (San Francisco: Friends of the Earth International, 1977).

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methods such as multistage particle filtration, UV irradiation, ozonation, or membrane filtration to purify water, bottle it (or refill customers' bottles), and sell it to the local population. Water quality can vary and government authorities often need to keep an eye on the entrepreneurs to make sure they do not engage in price gouging. Properly regulated, these small enterprises deliver safe water at affordable prices. In areas that experience considerable fog, it is possible to harvest water by capturing the fog and channeling the resulting moisture into barrels or older storage facilities. Areas that experience plentiful and regular rain can rely on rainwater harvesting systems. In some areas the collected rainwater can be used as it is but in others it requires some purification before being used for drinking. Rainwater harvesting obviously does not work very well in areas where there are lengthy dry seasons; people living in such areas will have to rely on other technologies.

The complexities that can arise in assessing what technologies are "appropriate" can be seen in reactions to one type of rural water collection technology. More than a thousand "roundabout play pumps" developed by a South African company are used by villages in five countries of southern Africa. The system attaches a playground merry-go-round to a water pump. Children playing on the merry-go-round by running with it to start it moving and then hopping on to ride provide power for the pump which delivers water into a 2500-liter tank standing about 7 meters (21 feet) above ground. Users access the water in the tank through a tap valve. Any excess water raised by the pump is diverted back into the ground. The storage tank also has panels on its four sides available for posting signs. Two carry advertisements yielding revenue that helps pay for maintenance of the pump. The other two carry public health messages, often focused on HIV/AIDS prevention. The pumps free women and children from the task of going to a more distant stream or other water source for drawing water and bringing it back home. This permits the children to spend more time in school and the women to devote more time to agriculture or other income producing activity. While the technology itself certainly qualifies as intermediate, some people question its appropriateness on two grounds. First, each pump costs several thousand dollars, a high price for a village. However, that problem is often solved by PlayPumps International, a transnational nonprofit foundation that raises money to pay for the systems. Second, there is some concern about the possible social consequences of using a system that encourages children to associate pumping water with "play". They fear this association will undermine efforts to encourage water conservation or teach children to be mindful of the environment.

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Appropriate Technology Exercise

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Task: You are an alternative technology consultant asked for advice by local groups in Leticia, Columbia and Tombouctou (sometimes spelled Timbuktu), Mali that want to bring more economical lighting to villages outside the city. After reviewing climate, geographic, and economic conditions in each area, write a memo to each group suggesting the lighting systems they should purchase and outlining the reasons for your recommendation.

Information Sources: Some sources for starting your information search include:

The countries

US CIA World Factbook (brief rundowns focusing on observable facts)
Colombia: https://www.cia.gov/library/publications/the-world-factbook/geos/co.html
Mali: https://www.cia.gov/library/publications/the-world-factbook/geos/ml.html

BBC News Country Profiles
Colombia: http://news.bbc.co.uk/2/hi/americas/country_profiles/1212798.stm
Mali: http://news.bbc.co.uk/2/hi/africa/country_profiles/1021454.stm

Lonely Planet Travel Guide and Travel Information
Colombia: http://www.lonelyplanet.com/colombia
Mali: http://www.lonelyplanet.com/mali

Equipment possibilities

Light up the World Foundation (affiliated with the University of Calgary)
www.lutw.org
See www.lutw.org/technology.htm for comparison of lamp types

Safe Bottle Lamp (developed by a Sri Lankan physician and produced locally)
http://www.safebottlelamp.org/

Lighting Africa Project (significant sponsorship by Philips N.V.)
www.lightingafrica.org

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IDEESE Module 1.3a Resources

Appropriate Technology Websites

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Below is a list of websites of some organizations advocating or distributing appropriate technologies.

National Center for Appropriate Technology (Butte, Montana, USA)
www.ncat.org

Development Center for Appropriate Technology (Tuscon, Arizona, USA)
www.dcat.net

KickStart (formerly AppropTEC) (London, England)
www.kickstart.org

Appropriate Infrastructure Development Group (Boston, Massachusetts, USA)
www.aidg.org

Practical Action (operating name of the Intermediate Technology Development Group, Ltd, a nonprofit based in Burton-on-Dunsmore, Warwickshire, England founded by E.F. Schumacher)
www.practicalaction.org

Centre for Alternative Technology (Machynlleth, Wales)
www.cat.org.uk

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IDEESE Module 1.3a Resources

Transnational Diffusion of Ideas and Technologies

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Diffusion of New Ideas, Practices, and Technological Innovations

I. The Basic Model of Diffusion

Most historians of ideas and technological change agree that the spread of ideas, practices, or innovations from the originators to others can be described by a hazard model. Hazard models, first developed in epidemiology and now used in many fields of social science, are mathematical formulations used to predict the likelihood that an individual will actually experience an event (such as developing a disease) within a particular time period given some risk (probability) that the event will happen to her or him. Whatever the level of risk of developing the particular disease, its cumulative spread through the population can be summarized with an S-curve plotted by placing time along the x axis and the number of new cases occurring in each time interval along the y axis. At first the disease spreads slowly because there are few sources of infection that trigger uninfected individuals in the process of exposure to germs, their incubation, and their overwhelming of immune system that culminates in disease. Even if the disease has a 75% transmission rate (three-fourths of those exposed to the germs causing to develop the disease themselves), each individual is unlikely to encounter someone who is contagious. Thus, the number of new cases increases slowly. As more people come down with the disease, however, a threshold is reached at which each individual's likelihood of encountering a source of infection increases significantly. In this second phase, indicated by the steeply rising portion of the S-curve, spread of the disease speeds up and the number of new cases per time interval increases exponentially. Spread enters a third phase once most people have been exposed to the disease, indicated by the slowly rising (or even flat) upper portion of the S-curve. With most people already exposed to the disease and only a few left who have not encountered it, the number of new cases per time interval drops. While the exact shape of the S-curve depends on the rate of transmission of the disease and the period of time needed for it to incubate in a newly-exposed person, the basic shape holds true for the spread of any disease that is not inhibited by effective preventive measures.

Studies of the diffusion of ideas, practices, and technological innovations substitute them for the germs of the disease model, and treat learning about their existence and content as the equivalent of exposure to a source of infection. Similarly, the rate of adoption of the new idea, practice, or technological innovation is

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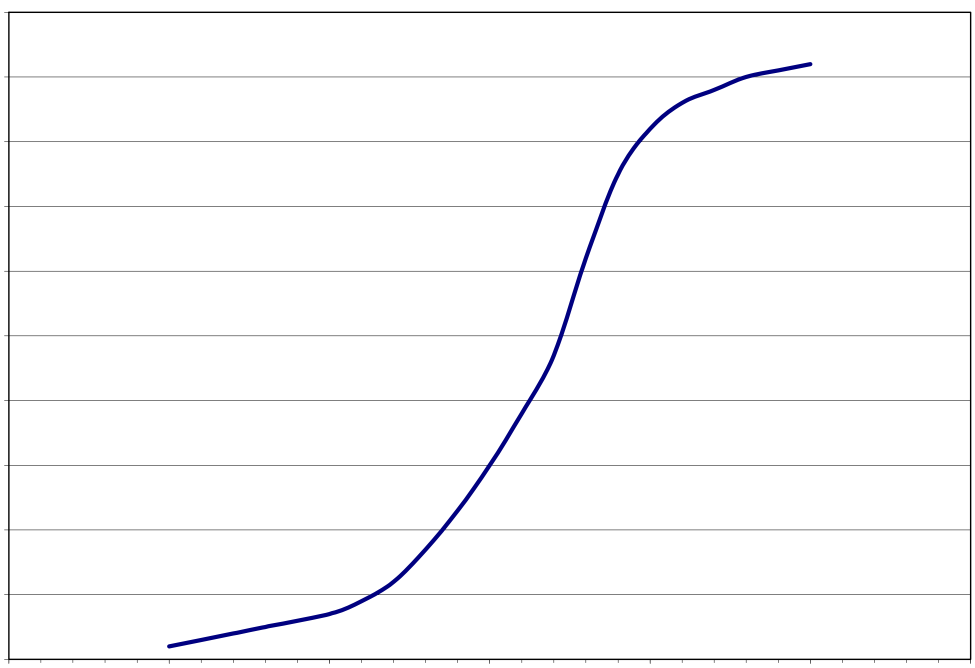
the parallel to the transmission rate of a disease, and the amount of time between learning about the idea, practice, or technology and deciding to whether adopt it is the parallel to the incubation period for a disease. Some analysts of innovation argue that the upward inflection point separating the first phase from the second occurs when somewhere between 10 and 25% of the population had adopted the new technology because that is when interpersonal "word of mouth" communication about it accelerates.[5] Yet, this is a wide interval and not particularly helpful for making predictions. In addition, many ideas, practices, technological innovations never diffuse beyond the circle of inventors and innovators. Others may diffuse a bit further, but never to the point where the S-curve moves from slow to exponential rise; for a variety of reasons most people decide against adopting them and using them.

Quantifying the adoption rate and the time between initial learning and the adopt/reject decision is harder than quantifying the transmission rate and incubation period of a disease. These obstacles to easy quantification mean that S-curve graphs work better for tracing past patterns of spread than for predicting future ones. Even so, the hazard model is a useful heuristic device because it alerts us to recurrent patterns and sensitizes us to the need for paying attention to phase transitions. In particular, it warns enthusiastic proselytizers of ideas or sellers of new technologies that explosive growth in the number of converts or buyers will not last forever.



An S-curve (hypothetical data)

The elements of the hazard model also direct attention to questions of what influences the likelihood that people will first learn about a new idea or technological advance and then choose to adopt it. Prior learning is necessary to (though not sufficient for) adoption, so anything that reduces the likelihood of learning about an idea, practice or technology (such as expression in an unfamiliar language, garbled messages in a familiar language, or censorship) or blocks access to a device or object embodying a technological

[5] E.g., Everett Rogers, *Diffusion of Innovations* (3rd edition. New York; Free Press, 1983), p.11.

innovation for trial use (such as distance from the makers, high cost of the device or object, or regulations limiting access to the device or object) automatically inhibits adoption.

Just as diseases spread from some initial source of infection to persons nearby, and then from them to a wider set of others, and so on, new ideas, practices and technologies originate with some individual or small group and then spread to successively larger circles of others. Diseases can make long geographic leaps if carried from one part of the world to another by infected travelers; learning about ideas, practices, and technologies can also span long distances through telecommunications and geographically dispersed social, professional, or business networks.

Yet, it is important to remember that learning about the new idea, practice, or technology does not automatically lead to its adoption. Amish communities are quite familiar with motor vehicles and telephones, but have chosen to restrict their use to a few very particular occasions and do not keep them within individual households. Japanese warriors became familiar with and used firearms in the early 17th century, but made and maintained a collective decision to avoid their use during Japan's era of isolation under the Tokugawa Shoguns between 1630 and 1854.

Both examples point up the importance of users' own evaluation of new ideas and technologies. Unlike germs, which are unwanted but can get past all of a person's hygienic precautions and immune system defenses, adoption requires willing acceptance. Analysis of the diffusion of technology typically distinguish among:

1.) "inventors" who come up with the initial version of the new technology;

2.) "innovators" who modify the initial version in ways that make the technology more attractive to potential users by increasing its reliability, simplifying the process of making it, or simplifying its use;

3.) "early adopters" who start using the new technology soon after it appears;

4.) "adopters" (sometimes divided into "early majority" and "late majority") who take it up after seeing a number of others use it;

5.) "late adopters" who take it up only after the vast majority of others have; and

6.) "nonadopters" who never use it although they know that it exists and that other people in their area are using it.

An individual or organization considering the adoption of a new idea, practice, or technology needs to be convinced that adoption will improve its overall situation. Sometimes the individual or organization considers its own situation in isolation from what others are doing. Such a focus clearly shaped the choice of the apocryphal Vermont farmer whose phone rings while a neighbor is visiting. The neighbor asks if he is going to answer it, and the farmer says "Nope; I put that thing in for *my* convenience." More often, however, the fact others are using a particular idea, practice, or technology strongly influences the decision. This is particularly true in competitive situations – such as prevail between armies, business firms, or sports teams – where any new idea, practice or technology that gives its users any advantage must either be adopted or understood well enough to develop effective defenses against it. Others' use also affects decisions about whether and when to adopt any technology with "network effects" – increasing value to users as larger number of others also adopt it.

Studies of diffusion have identified several factors that affect the rate of adoption of a new technology in a single country or community:

1.) Characteristics of the technology itself or in comparison to competing technologies;

2.) Economic benefit/cost ratio of using the new technology;

3.) Mode of social decision about adopting new technologies;

4.) Communication channels used to promote the new technology;

5.) Social and material conditions in which the technology will be used; and

6.) Extent of promotion by trusted persons;[6]

Characteristics of the technology include its own features, its functionality as compared to other technologies for accomplishing the same task, and its feasibility within current technological attainments. The important features of the technology itself include ease and convenience of use, compatibility with technologies already in use, fit with prevailing social expectations, and the extent to which users can try it out temporarily or on a small scale before having to commit to adoption or non-adoption. Cost and ease of use as compared with other technologies is also important, though users will accept a short period of inconvenience as they master the new device if they believe gains in convenience or effectiveness will repay that effort. Feasibility within the limits of current technological attainments determines whether the idea for the technology gets expressed in a physical device. Many inventors get good ideas before fabrication technologies are well enough developed to permit making devices based on them. Sir George Cayley, a prosperous landowner in Yorkshire, England worked out the basic design for airplanes – a wing to get lift from moving air, a propulsion device to get the moving air by moving the wing through it, and tail rudders for steering – in 1809. However, his design was not realized until 1903 when internal combustion engines proved capable of supplying the right combination of sufficiently lightweight and strong power.[7] Sometimes the state of complementary or related technologies – technologies that need to be used together with the new invention for it to work well – are insufficient. A working fax machine was exhibited at the Crystal Palace Exposition of 1851, but it was not until the transmission speed of phone lines got up above 3000 bits/second in the 1970s that fax connections convenient and affordable for users in small offices or stores became available.

Cost-benefit ratios of use also influences adoption rates. Though high cost directly limits adoption, most economic calculations affecting acquisition involve comparison with the cost of other ways of doing the

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[6] Everett Rogers, *Diffusion of Innovations* (3rd edition. New York; Free Press, 1983).

[7] J.A. Bagley, "Aeronautics" in Ian McNeil, editor, *An Encyclopedia of the History of Technology* (London: Routledge, 1990), 619-624.

same task. High cost did help confine telephones to upper and upper middle class homes in Europe and North America in the 1920s. In Sweden households within 1 kilometer of a large telephone exchange were more likely to have phones than others because the more distant households had to pay the National Telecommunications Administration the cost of running wires to their houses before service would be installed.[8] This initial cost dampened their enthusiasm considerably. Yet, relative benefits-cost ratios are typically more important. Many businesses that might have opted for telephones found that by careful phrasing or use of any of the many published abbreviation systems ("commercial codes") available, telegrams were cheaper than telephone calls for urgent long distance business communications until well into the 20th century. City dwellers in the 1920s found it cheaper to garage and run a modest-price automobile than to house, feed, and equip a horse.

The *mode of decision-making* used to select new technologies also affect the rate and extent of adoption. Societies in which individual persons, households, or firms are allowed to choose on their own have different diffusion patterns than those where the adoption process involves collective decisions among all members of an extended social group or decision for a large group by a small leadership. In the collective decision situation, individual limited trials may occur, but general use develops only after a social consensus in favor. Until that consensus emerges, the graph of adoptions over time will be flat and close to 0 on the y-axis. Afterward, the rate of adoption will rise, but how steeply depends on whether the consensus is a decision that everyone most adopts the technology or a decision permitting adopters to go ahead and nonadopters to persist in their choice. Similar patterns mark centralized decision, though in this situation trials are controlled by the leadership and debate about whether to adopt is confined to a few. Even where decisions are made individually or by local communities, government regulations and taxes can encourage or hinder adoption of new technologies. Many governments promoted aviation in the 1920s and 1930s through subsidies. The contemporary US dependence on motor vehicles can be traced partly to policies favoring road and highway construction; conversely, high fuel taxes helped constrain household possession of automobiles in Western Europe.

Two *communication channels*, mass media and person-to-person contact can spread ideas about new technologies. Mass media are most effective for disseminating information that a new technology has been incorporated into devices very quickly, person-to-person communication between users and non-users among their family, friends, or occupational networks have the most impact on adoption decisions.

Social and material conditions also affect diffusion. Political and social stability encourages longer-term projects by promoting confidence that they can be finished and their results enjoyed. Technologies may intertwine with social factors that encourage or inhibit use. In the 1960s and 1970s fax technology was more popular in Japan than telex. Telex is a character-based system, an automated telegram system in which the sender types characters on a keyboard and the machine converts them into the Morse dot-and-dash code used on the wire and the receiving machine converts the Morse code back into characters and prints them out on paper while fax technology reveals characters as output of line-by-line scanning of light and dark areas. Japanese users liked fax because it is much easier to scan than to type out the 4000 characters of Chinese ideograph-based *kanji* and additional syllabic characters of *kana* script used in written Japanese. Desire to "keep up" with the neighbors means that households in neighborhoods where most others have acquired a particular new device – say a color television in the 1960s – will be more likely

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[8] Torsten Hagerstrand, *Innovation Diffusion as a Spatial Process* (Allan Paul, trans. Chicago: University of Chicago Press, 1967), 53.

to buy one than households in neighborhoods where few others have them. Adoption of technologies incorporated into obviously expensive devices may be hindered by social beliefs that possession inspires envy and the envious respond by invoking witchcraft against the envied person.[9] Studies of farmers' adoption of new irrigation technologies have shown that soil quality and depth of the water table are major determinants of farmers' choices regarding irrigation.[10]

Individuals trusted by others in the community can foster or hinder adoption of a new technology. In every community others look to certain people for guidance because of some role they occupy or a reputation for wisdom. In many countries farmers' technology choices are strongly influenced by what government-employed agricultural agents recommend or warn against in the course of their work. The Nestlé campaign to promote use of baby formula in developing countries succeeded as well as it did (and attracted as much vehement objection as it did) because the women hired to promote it often dressed in a manner similar to medical clinic staff.

The existence of so many influences on technology choice mean that the route from learning about a technology to using it regularly is more complex than the route from encountering germs to coming down with a disease. Unlike the pathway from germs to disease, the pathway from learning about a technology to using it regularly involves physical, social, and individual factors. Yet, the hazard model does capture broad patterns. The answer to the puzzle about how something influenced by many factors can be expressed in similar patterns has two parts: a) the pattern has considerable variation in the timing and speed of its phases and b) innovators and other advocates of a technology pay attention to potential users' reactions and often modify the devices embodying the technology or their explanations of what the technology can do to fit their audience. It is frequently the case that the early devices using a particular technology bear little resemblance to the later ones; the vacuum tubes and mechanical card readers of the Univacs of the 1950s bear scant resemblance to the silicon chips and magnetic hard drives of contemporary computers.

II. The Impact of National Differences on Diffusion

The simplest hazard models assume an undifferentiated population in which each individual has about the same likelihood of encountering any other nearby individual and influences pass freely between them. More sophisticated ones are able to accommodate differentiated or segmented populations in which the likelihood of encounter is high within a subgroup and low between subgroups. The transnational diffusion of ideas, practices and technologies involves segmented populations because national boundaries and cultural differences insert additional filters through which learning about new ideas, practices, or technologies must pass.

Though national borders do not form as strong a barrier to communication as they did in the past, some countries still succeed in walling off their populations from global information flows. North Korea is the most successful today, but most dictatorships limit local access to foreign-origin information. To the extent that a

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[9] Liliana Goldin, "Work and ideology in the Maya highlands of Guatemala," *Economic Development and Cultural Change* 41/#1: 103-4 (Oct. 1992) notes such beliefs were common among Maya in Guatemala.

[10] E.g., M. Caswell and D. Zilberman, "The effects of well depth and land quality on the choice of irrigation and technology," *American Journal of Agricultural Economics* 68: 798-811 (1986) and G. Feder, R.E. Just, and D. Zilberman, "Adoption of agricultural innovations in developing countries: A survey," *Economic Development and Cultural Change* 33: 255-298 (1985).

government can make national boundaries into barriers excluding communications from outside, they prevent learning about inventions and innovations and keep adoption decisions from arising at all. Even when borders are permeable language differences channel the direction of information flows. Translation can widen the flows, but it only occurs when someone (perhaps the originator of an idea or invention; perhaps an early adopter who wants to spread it) decides that a particular piece of information is important enough to justify the work involved. The spread of English as a second language around the world has reduced some of the barriers between countries, though may accentuate the differences of information open to the more privileged and to the less privileged within countries because the former are much more likely to have opportunities to learn English.

When communication succeeds, cross-national differences in adoption reflect different conjunctures of the same six factors that influence adoption in a single country.

While the *characteristics of the technology itself* may remain constant, the comparisons to competing technologies can differ considerably because they depend on what else is available. Where batteries are easily obtained, a wind-up flashlight will be a distant second choice after a battery-powered flashlight; households will not acquire them, or will only have them for emergencies in case all batteries on hand are run down. Where batteries are scarce, a wind-up may be the only choice.

The *economic cost-benefit ratios* of new technologies may be radically different in various places because of differences in physical environment, factor endowments, local operating skills, or cost of infrastructure and supplies needed to keep the technology running. The economics of using solar cells are very different in the Sahara than in rainy Seattle or the dark Arctic winter. A constant national labor shortage greatly reinforced 19^{th} Americans' efforts substitute machines for humans in as many areas of production and housework as possible; plentiful labor meant the need to invent or acquire labor-saving machinery was much lower in China or India. Local skill levels can increase, and governments use policy devices like expedited residence permits for skilled immigrants, requirements that foreign firms allowed to operate in the country train locals for skilled jobs, or hiring foreign instructors to staff technical schools and colleges to increase the local skilled labor pool. However, technology choices do depend on current and near-future skill attainments rather than long-term potentials. Extending a national electric grid is much easier in countries where most people live in large cities and concentrated villages than in countries where most of the population is spread thinly across vast deserts, and absence of reliable electricity constrains many technology choices. One can cook food in the Gobi Desert, but using an electric stove is usually not an option.

Differences in the *mode of social decision* about adopting new technologies may or may not yield differences. Advocates of participatory decision-making tend to assume that an open process leading to collective consensus decision will result in using technologies that are less centralizing and less risky than those chosen in either an elite-run decision processes or a system of individual choice (because the wealthiest will be able to operate at a scale overshadowing everyone else), but that is a proposition that needs further testing. In a world of open communication, it may be harder for elites than for cohesive social groups to exclude unapproved technologies or unapproved uses of approved technologies. In a cohesive social group, mutual regard and respect for the tradition of consensus provide effective barriers against individual technology wandering. Elites may enjoy comparable legitimacy but when they do not they are likely to face the sorts of individual wandering in which Iranians put sermons and revolutionary messages

from Ayatollah Khomeini into their cassette recorders and residents of the Baltic republics connected to the Swedish cell phone system rather than use Soviet landlines.
Differences in communication channels can have an impact. Fewer mass media outlets that reach a smaller segment of the population appear by definition to be less effective at disseminating information about ideas, practices, and technologies. Though paucity of mass media does not necessarily mean people cannot get information[11] but informal oral networks are not the best ways to circulate detailed technical information. Without ways to secure more detail, the discussions between users and family, friends, or occupational contacts that most influence adoption decisions may not be as effective.

Social and material conditions in which the technology will be used have an impact, but many technologies can be used in under a variety of conditions. Minnesotans need down parkas while Nigerian villagers do not; but both can wear tee shirts. Some technologies are perceived as culturally relevant, and adopted or resisted on cultural grounds; others are perceived as culturally neutral. Cassette tape recorders, initially developed with the idea that people would use them to have a portable source of musical entertainment, were quickly adopted by political dissidents ranging from Marxist guerillas to Islamicist imams for spreading their message.

Culturally based reactions to foreign origin technologies depend very much on the *extent of promotion by trusted persons*. Many studies of the cross-border spread of ideas and technologies acknowledge that their reception depends on their fit with already prevailing local models. Those that can be presented as consistent with local norms are more likely to be accepted than those that cannot. Colonial units in India willingly accepted new rifles in the 1850s since weapons are central to soldiering. Suggestions that the grease on the cartridges that had to be bitten before loading them into the rifles came from pigs or cows fanned the preexisting discontent among some Moslem and Hindu soldiers into mutiny because the grease was now seen as violating religious dietary laws. Even the name given to a device can affect the likelihood of adoption if locals interpret it in different ways. The most famous commercial example is the marketing fiasco of Chevrolet's attempts to sell its Nova model in Latin America. Chevrolet had named it with the Latin word for "new," but locals read the name as "no va" ("doesn't go") instead. Community influentials who dislike a foreign idea, practice, or technological innovation can discourage adoption by castigating it as contrary to local morals, likely to destroy local ways, or creating unwanted dependence on outsiders. Those who like it can promote adoption through both talking about it and by using it; their words and deeds indicate how it can be incorporated into local culture without severe negative consequences. People who are unhappy with local ways might even adopt a foreign idea, practice, or technological innovation as a way of expressing their unhappiness with and desire for change in the current situation.

The strong differences of climate, topography, economic factor endowments, and cultural heritages between industrial and developing countries around the world have inspired concern that many countries, particularly smaller and poorer ones, end up with technology that fails to meet their real needs. This is often attributed to the influence of multinational corporations, but there are actually three reasons why persons, groups, local business firms, or the government in a country acquire inappropriate technology:

1.) the whole set of currently known and used technologies is inappropriate to a particular country or activity within it,

[11] In many African countries the rumor flows known in francophone countries as *radio trottoir* (pavement radio) often make up for scanty broadcast media. See Stephen Ellis, "Tuning in to pavement radio," *African Affairs* 88 (#352): 321-330 (1989).

2.) inappropriate technology is acquired because no one in the country providing information to the choosers knows about the appropriate technologies that exist, or

3.) the choosers know about appropriate technologies but choose inappropriate ones.[12]

Since multinational corporations are not the only source of technology in the world, they are not solely responsible for instances of the first problem. They could be the source of the second and third problems through selective presentation of information or hard bargaining, but as governments, locally owned firms, and others in developing countries acquire greater awareness of available technologies and greater ability to compare them knowledgeably the bargaining balance is shifting. In the meantime a significant "appropriate technology" movement,[13] given more impetus by rising concern for ecological sustainability, seeks to remedy all three problems through developing technologies designed specifically for conditions in poor countries, publicizing all technologies they regard as appropriate, and developing contacts with technology choosers.

In cross-border as well as within country situations, the hazard model is a summary of patterns that result from the aggregate of technology choices. In so doing, they obscure the activities of promoters and discouragers of new technologies, innovators, firms, governments, and others often seek to influence the cross-border spread of ideas and technologies. Innovators generally want to see their innovations adopted widely. Some business firms prosper by encouraging use; both cellphone network providers and cellphone manufacturers prosper when usage spreads. Other firms prosper through patents and licensing; they want licensees but not unauthorized copiers. Governments both encourage diffusion of particular technologies through their foreign aid programs or other subsidies, and constrain diffusion through export controls. Private "non-profits" (foundations, institutes, advocacy organizations) have been strong supporters of programs to develop and distribute higher-yielding varieties of plants commonly grown for food in developing areas; they also helped disseminate birth control drugs and devices. Others have campaigned against the use of certain technologies, particularly the products of nuclear engineering, genetic modification, and animal cloning.

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[12] Frances Stewart, *Technology and Underdevelopment* (Boulder, CO: Westview Press, 1977), page 3.

[13] Inspired initially by E.F. Schumacher, *Small is Beautiful* (New York: Harper and Row, 1973).

IDEESE Module 1.3a Resources

In Class Evaluation

Version 2; July 2010

Part 1: The following are some possible response you might have to the material in this Module. Please circle the response that is closest to your thoughts after this module.

Key	
SA	Strongly Agree
A	Agree
UN	Undecided
D	Disagree
SD	Strongly Disagree

Statement	Your Response				
1. I now realize that there is a lot more communication and interconnectedness between countries than I realized.	SA	A	UN	D	SD
2. I do not think that it is very important for scientists/ engineers to pay attention to the international aspects of their work.	SA	A	UN	D	SD
3. I realize that my career will probably have some global or international aspects.	SA	A	UN	D	SD
4. I now realize there are more social implications related to my career than I thought about previously.	SA	A	UN	D	SD
5. I am more aware that the work I might do will involve ethical as well as technical choices.	SA	A	UN	D	SD
6. I am more aware now of the complications related to different ethical expectations in different countries.	SA	A	UN	D	SD
7. I feel there should be one set of ethical guidelines developed that could be used to guide the work of scientists/engineers, regardless of the country in which they work.	SA	A	UN	D	SD
8. I feel that each culture has its own ethical standards, and those standards should not be dictated by other cultures or countries.	SA	A	UN	D	SD
9. I think that ethical guidelines should be a part of international treaties.	SA	A	UN	D	SD
10. I think that it is sufficient for an international company to comply with each nation's ethical standards, independent of the location of the company's headquarters.	SA	A	UN	D	SD

Part 2: In this section, please identify one specific example that you remember as having the most impact on you. Please leave the line blank if nothing seems relevant.

1. Increased intercommunication that exists now between countries.

___

2. Social implications of work done by scientists and engineers.

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3. Decisions about ethics in relation to different countries.

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4. Any other specific ideas that were important to you from this module.

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<end>

This was created by the International Dimensions of Ethics Education in Science and Engineering (IDEESE) Project at the University of Massachusetts Amherst with support from the National Science Foundation under grant number 0734887. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. More information about the IDEESE can be found at http://www.umass.edu/sts/ethics.