

# Lecture # 21 – Technology in Developing Countries

## I. Improving Access to Existing Medicines

- Even when medicines are available, any people who need pharmaceuticals in developing countries do not receive them.
- Moreover, in emerging economies, many of the same chronic diseases prevalent in high-income countries, such as heart disease and cancer, are becoming common
- The initial controversies occurred in the late 1990s in Brazil and South Africa over access to medicines for HIV/AIDs
  - Brazil
    - Before 1996, drugs could not be patented in Brazil. Patent protection was instated as a result of TRIPs.
    - The 1996 law says that, to maintain a patent, the patent owner must use the technology in Brazil.
      - Simply importing the technology is not enough to fulfill this requirement.
      - U.S. pharmaceutical firms claimed this violates the W.T.O. treaty.
        - They fear that this clause could be used to invalidate many other patents.
    - In 1999, the Brazil president allowed government licensing of patents in a national emergency.
      - The law says companies must provide sufficient information for the reproduction of the product.
      - This provision has been used to ensure access to AIDS medications.
        - Not surprisingly, US pharmaceutical firms object.
    - Brazil has successfully provided generics to its people.
      - Before 1997, Brazil copied drugs patented elsewhere.
      - Since 1997, it now licenses AIDS drug patents to government laboratories.
    - In May of 2001, Brazil's health minister proposed a vote at the World Health Organization (WHO) condemning the use of trade agreements to obstruct poor countries' access to cheap medicine.
      - In a similar vote at the UN Human Rights Commission, only the US voted no.
  - South Africa
    - In 1997, South Africa passed the Medicines and Related Substances Control Act.
      - The Act gives the state more flexibility obtaining medicine.
      - It eliminated price markups and encouraged the use of generics.
    - 39 pharmaceutical companies sued in 1998, claiming that it violates the constitutional right to patent protection.
      - Arguments

- South African government
  - Thousands are dying, and many of these deaths could be avoided.
  - They claim patents make the drugs unaffordable.
  - Options:
    - Parallel imports
      - If the state can find cheaper supplies of a patented drug abroad, it can import from a country with weaker IP laws without the patent holder's permission.
    - Compulsory licensing
  - Drug companies
    - The proposed compulsory licensing gives the health minister too much discretion.
    - Adequate compensation is not provided for taking the IPRs.
    - Companies fear that generics aimed at the poorer parts of South Africa will also leak into the lucrative private market in South Africa.
    - In 2000, five drug companies offered certain African countries, including South Africa, discounts of 70-90% on several HIV drugs. Few governments took the offer.
- The companies, fearing competition from generics, have lowered prices.
  - The government says the prices are still too high.
- After Canada ended compulsory licensing for drugs in 1993, R&D by drug companies increased (\$900 million in 1999, vs. \$166 million in 1988).
  - However, is this relevant for developing countries? Do they have the scientific infrastructure to do R&D?
- Follow-up:
  - The pharmaceutical companies dropped their suit on April 19, 2001, and agreed to pay the country's legal costs.
  - They acknowledged that the law complied with international trade agreements.
  - The drug companies and the government will collaborate to rewrite the most controversial aspects of the law.
  - Concern of activists at Doctors Without Borders
    - The deal came about because of concern of competition from Indian generics.
    - However, because of TRIPS, India will need to enforce drug patents by 2006.
    - In October of 2002, the U.N. Global Fund to Fight AIDS, Tuberculosis and Malaria allowed fund money to be used to purchase generic drugs.

- Countries must buy the lowest priced drug, but only drugs of guaranteed quality and that comply with both national and international laws.
    - Thailand
      - In late 2006, Thailand announced it would overrule patents for Efavirenz, an anti-retroviral drug made by Merck.
        - Thailand would switch to a generic made in Thailand for half the price.
        - TRIPS allows such compulsory licensing.
          - Other countries, such as Brazil, Malaysia, India, and Kenya have followed or are considering following Thailand's lead.
      - Issues:
        - Is this valid under TRIPS?
          - Drug companies say compulsory licensing is to only be used as a last resort, such as national health emergencies.
        - Note that this strategy is used by middle income countries that are capable of producing generics, rather than the poorest countries.
          - How will poorer countries be affected?
            - TRIPS allows them to use compulsory licensing and purchase generics from other countries.
            - Canada encourages production of generics to meet these markets.
            - However, their costs, and thus their prices, are high.
          - Should drugs be priced on a sliding scale (e.g. per capita GDP)?
            - Middle income countries could be charged more than low-income countries.
        - Will this discourage MNCs from working on developing country issues?
- As a result of earlier controversies, international development assistance for health grew more than 10% per year from 2001-2010
  - Annual R&D funding for HIV/AIDS, malaria, TB and other infectious diseases rose by a factor of 30
  - Competition and voluntary price cuts dropped price of antiretroviral medicines (ARVs) from \$12,000 per year in 2001 to \$200 per year in 2005
    - As a result, use of compulsory licenses fell
- New controversy in 2012 concerns non-communicable diseases (NCD) – e.g. heart disease, diabetes, cancer
  - Key policies/rulings

- India court refused a patent to a modified version of Gleevec, an anti-leukemia drug
- India issued a compulsory license for a treatment of liver and kidney cancer
- India pressured Roche to surrender its patent rights to Herceptin, a treatment for breast cancer that cost \$18,000 per treatment
- India ruled a patent held by Bayer for Nexavar, a cancer drug, to be valid but overrode it anyway to allow a generic company to produce
  - Cost fell from \$4,500 per month to \$140 per month
  - Generic will only be allowed for use in India
  - Only the second country (Thailand first) to use compulsory licensing for a cancer drug
    - Raises question about whether it is an “emergency”
  - Court ruling said justified because the drug needed to be made available at a “reasonably affordable price” (based in 2005 law)
    - Bayer argued that reasonableness should consider development costs.
- Indonesia announced a compulsory license for seven drugs
- China and the Philippines amended patent laws to make it easier to use compulsory licenses for medicine
- Motivation
  - Toll of NCDs increasing in middle-income countries
    - As a result of progress against infectious diseases, people live longer and succumb to chronic illnesses
      - Such chronic illnesses are now responsible for 2/3 of deaths worldwide
  - Access to treatment for NCDs remains low
    - Women in India are less likely than women in the US to get breast cancer, but more likely to die from it
  - Because these countries have higher incomes, there is less support from industry for offering low prices
  - These countries have domestic manufacturers that benefit from weak patent protection on imports
- What can be done to improve access?
  - Donor support for innovation on low-cost treatments for NCD
    - Current treatments are aimed at developed country markets
  - Financial incentives and pooled procurement
    - Many off-patent treatments are unavailable in developing countries because there are no international suppliers
    - Advance market commitments could help here
  - Differential pricing within countries
    - If pricing was based on income of patient, rather than the country, firms may be more amenable to low prices for some
      - Most drug purchases are out-of-pocket in lower and middle income countries. Hard for low income families to afford

- 70% of the people living on \$2 per day or less live in middle-income countries
    - May need licenses for local generic producers to meet demand
  - It is important for policymakers to realize that this is not taboo. Prohibiting it could hurt developing countries.
  - Developed countries could help promote price discrimination by prohibiting imports of pharmaceuticals from countries with weaker patent laws.
    - Would prevent re-importation, but would it be politically feasible?
  - However, if the market for a drug is small (e.g. only for developing countries), prices will still need to be well above marginal costs to compensate for fixed R&D costs.
  - These diseases affect patients in both low-income and high-income countries
    - How do we respond to consumers in the US who as why they have to pay so much more for these medicines than people in India?
    - This was less of a concern for infectious diseases
- Drug regulation and procurement
  - Is regulation and approval necessary?
    - While it is costly to have drugs hit the market prematurely, is it also costly if drugs are delayed?
  - Should developing countries wait for developed country approval?
    - Many developing countries simply follow the lead of developed countries.
    - This may slow diffusion.
      - For example, the US withdrew approval for an oral rotavirus vaccine in 1998 because of concerns over intestinal obstruction.
      - Since the disease is more prevalent in Africa, it may be worth the risk.

## II. Leapfrogging

- Leapfrogging
  - Leapfrogging follows from the notion that possibility that technological change is not linear.
  - Developing countries can adopt a new technology directly, skipping over earlier inferior versions.
  - Examples
    - Cell phones vs. landlines
    - LED's vs. incandescent light bulbs
- Advantages
  - Get better quality

- For example, the US had color TV first. However, other countries have better technology standards for color TV.
    - Technologies can spread faster in countries that adopt later
      - However, there appears to be more variation in developing countries.
      - As we'll discuss next, there is more inequality in diffusion in developing countries.
        - A World Bank report in India looked at several Indian industries, including drugs, food, car parts, and textiles.
          - In most cases, each industry had a few highly productive companies and several laggards.
          - Calculated that national income in India could be 4.8 times higher if all enterprises simply absorbed the knowledge already in the economy.
    - No need to dispose of older, dirtier models
      - E.g., no refrigerators with CFCs
  - However, the technologies available for leapfrogging are usually determined by developed country tastes.
    - For example, there are better treatments for HIV than malaria
- Key lesson
  - Technological progress in developing countries need not follow the same path as developed nations.
    - India, for example, is moving quickly to a service economy
  - Counterexample:
    - Kodak mistakenly assumed could sell film cameras in China after developed world went digital.
    - Instead, China moved right to digital and camera phones
  - Cell phones are an excellent example of leapfrogging
    - No need to wait for landline infrastructure to develop, which can be expensive
    - Cell phones typically introduced by private companies, rather than the government
      - Firms see them as profitable
  - What helped encourage spread of cell phones?
    - Development of two main technology standards and economies of scale in high income countries, which reduced costs.
    - Note that the market for cell phones is different in lower-income countries
      - Phones compensate for infrastructure
      - Phones being used for banking
        - Use of mobile phones to pay bills and do other basic banking in many African countries
        - Equity Bank in Kenya uses vans with laptops and telecommunication devices as mobile banking units
          - Particularly useful in rural communities
        - Regulatory hurdles hinder development

- Often vested interests are a concern.
  - How were developing country markets different?
    - Different billing systems – cash important
      - Prepaid plans reduce need for credit
    - Lower cost phones needed
      - Phones often shared
      - Avoids fixed cost barriers for consumers
    - Need to get past regulatory barriers
      - More phones where there is more competition
      - In Ethiopia, mobile phones still a government monopoly in 2008
        - Only had diffusion of 3.5%, compared to 40% for Africa as a whole
  - Different business models evolved
    - Fuel needed to power base stations, which run on diesel
    - Lower revenue per customers leads to:
      - Outsourcing
        - Economies of scale for vendors
      - Sharing infrastructure
        - Sharing moved from developing countries to developed countries (EU)
      - Pre-paid plans
      - Different pricing, such as dynamic pricing
        - Consumers are more price sensitive
    - Note that partnering with local companies helps
      - MNCs might not have the expertise needed to succeed in local markets
- In addition phones have secondary benefits that might not be observed elsewhere
  - The *Economist* article notes how fisherman use their phones to learn about the price of fish
  - Rather than sell fish at beach auctions, they could call around for the best price
  - The proportion of fisherman going beyond home markets to sell their catch rose from zero to around 35% after cell phones were introduced
    - Avoids waste, as before fisherman would throw fish away if the home market was oversupplied
    - Could happen, for example, if the local fishing ground has a good day. The catch will be high for all local fisherman, driving prices down.
  - Benefits
    - Fishermen's profits rose 8%
    - Fishermen recouped the cost of phones in two months
    - Consumer prices fell 4%

### III. Diffusion in Developing Countries

- So far, we've focused on getting technology to countries.
  - There is evidence that this is happening faster than before.
  - Examples of the time until a product was introduced in 80% of countries:
    - 19<sup>th</sup> century technologies took nearly 100 years
      - Trains 125
      - Open hearth furnace 125
      - Telephone 99
      - Electrification 78
    - Early 20<sup>th</sup> century technologies
      - X-ray 93
      - Aviation 60
      - Radio 69
      - Television 59
      - Dialysis 33
    - Late 20<sup>th</sup> century technologies
      - Heart transplant 28
      - Personal computer 24
      - Internet use 23
      - CAT scan 18
      - Mobile phones 16
  - Leapfrogging may occur
    - E.g. some lower income countries have more penetration of cell phones than of land line phones
    - Varies by technology
      - Personal computers have diffused more slowly than cell phones or the Internet
        - Infrastructure is an issue
          - Need access to electricity to use a PC
        - Can go to an Internet café for Internet access
        - For Internet in Sub Saharan Africa, use satellite rather than broadband connection, making it more expensive
      - 3G mobile phones are a lower cost solution to infrastructure deficiencies
        - Can share fixed costs
        - In contrast to older technologies, cell phone network investment has primarily been by private sector, often in a competitive environment
  - Mechanisms that speed diffusion
    - International trade
    - Foreign investment
    - Emigrants to the West



- However, patterns of diffusion within developing countries also differ from developed countries.
  - In industrialized countries, once technologies reach the country, they almost always achieve mass-market scale (25% of market)
    - Of 28 technologies studied by the World Bank, 23 reached 50% in industrialized countries.
  - In developing countries, there is more disparity
    - Of 67 technologies reaching 5% penetration in developing countries, only 6 reached a 50% market share
    - For example, In India, 52.3% of urban households have fixed or mobile phone service. Only 6.5% of households in rural areas have such service.
- Diffusion patterns vary for old versus new technologies. Diffusion of older technologies
  - Affordability often limits access to key technologies, such as electricity and land-line telephones (see table 2.3)
  - It is more than just income that matters, however, as there is much variability across countries. Other factors include:
    - industrial structure
    - tax policies
    - preferences
    - regulatory climate
  - Electricity
    - Most Soviet bloc countries have near universal electric power
      - Emphasized under communist rule
    - In other countries, access is concentrated near large cities
      - In India, only 85% of rural villages have access to power grid
      - In Sub-Saharan Africa, only 8% of rural population has access to grid, compared to 51% of urban population
    - Reliability of grid also varies
  - Phone lines
    - Affordability varies by income
  - Medicine
    - Diffusion of knowledge within the medical community is rapid, but widespread diffusion within a country often slow.
    - Low immunization rates are an example
- Extensive versus intensive margin
  - Extensive margin: is the technology present in a given country
    - Until the industrial revolution, differences across countries were relatively small
    - Can be extended to disaggregated levels, using penetration rates leading to the S-shaped diffusion curves
    - Doesn't capture intensity of use
  - Intensive margin: focus on intensity of use
    - Data are more difficult to come by
    - When available, differences across countries are substantial

- Correlated across income and across technologies
  - Logistic curves (e.g. S-curves) do not fit data for intensity of use as well
    - Flatter curves, with shifts between countries (e.g. starting points), are more typical
- Note that countries with similar income levels can have different levels of technological achievement (figure 2-10)
  - Top performers in developing country income groups have ratings similar to the median country of the next highest income group
    - There is much dispersion at any one level of income
    - The lines plot the relationship between income and technological achievement for different regions
      - Tends to flatten out between \$10,000 and \$25,000
    - Lower level of achievements in Latin America than Europe and Central Asia
- What matters for diffusion?
  - In general, two factors are important:
    - Exposure to technology
      - Here, trade, FDI, and emigrants matter
    - Ability to absorb
      - This includes both education and policies that make investment desirable
      - I focus on factors affecting absorptive capacity below.
  - Note that it is more than income that matters
    - India and Bangladesh have similar GDP, but electricity losses are 30% of output in India, 10% in Bangladesh.
    - Africa has low mobile phone use, but in 6 countries, more than 30% of the population uses
    - High tech imports are less than 7% of total imports in Argentina and Columbia, compared to 1/3 of imports in East Asia.
    - This is especially true for older technologies
      - These required greater investment in infrastructure and more skilled workers.
      - As such, government policy was important.
    - However, note that income is not irrelevant.
      - For example, in India, smaller firms use less advanced technologies than larger firms
  - History
    - Technologies are often cumulative. Countries that failed to adopt earlier technologies are at a disadvantage
    - This is a problem for Latin American countries that pursued an import substitution strategy.
    - Comin and Hobjin (2004) consider adoption of new and predecessor technologies

- Predecessor technologies are earlier related technologies (e.g. newspaper before radio, radio before TV; rail before vehicles, vehicles before aviation)
  - They find a positive relationship between adoption of predecessor and new technologies
  - Suggests there are inputs in adoption process that are transferable across technologies within a sector
- Infrastructure
  - Cannot have IT diffusion without a reliable electric grid
  - Ex-Soviet economies do well here, because central planners built lots of electricity lines.
  - In Latin America, consume ½ the electricity per person as eastern Europe and Central America
  - Call centers in Kenya pay 10X as much for bandwidth as in India, due to poorer fiber-optic cable system in Kenya
- Regulatory framework
  - How inviting is the country to investors?
  - Are contracts enforceable?
  - How easy is it to start a new business?
    - According to the World Bank, an entrepreneur starting a new business in a developing country must undertake an average of 9 separate procedures, taking almost 50 days to complete. In high-income OECD countries, the entrepreneur would need to complete 6 procedures taking an average of 17 days.
  - How readily is capital available?
    - In East Asia, most R&D from private companies.
    - In Latin America, most R&D from the government, and universities do most of the work.
    - Since firms are closer to markets, they are better at adaptive R&D.
  - How easy is it to navigate customs? To track shipments?
  - Does the government prop up unsuccessful companies, thus stifling innovation?
  - Is labor mobility restricted?
  - Is the country politically stable?
  - Strong property rights important for diffusion
  - Lobbying and rent seeking by stakeholders of existing technology can slow diffusion of new technology
    - As a result, Comin and Hobjin (2009) find that more independent legislative power in a country slows diffusion, as it makes rent seeking less costly
  - Open trade policy
- Other absorptive capacity issues
  - Are there rural/urban education differences?

- Patenting adaptive innovation may be difficult, reducing incentives for adaptation.
  - Knowledge
    - Can be human capital, but also may be embodied in organizations or in sectors
      - E.g. absorptive capacity of an organization may be more than just the human capital of its workers
      - The organization's collective experience also matters
    - Comin and Hobjin (2004) find that the effect of education varies by technology
      - Education is very important for adoption of communication technologies, computers, and electricity
      - Less important for transportation technologies, steel production
  - Geographic interactions
    - Acquiring knowledge depends on interactions
    - Interactions are shaped by geography
      - E.g. farmers tend to imitate their neighbors
        - Foster and Rosenzweig (1995) find that profitability of high-yield seeds in Indian villages increases with neighbor's experience with the seeds
        - Conley and Udry (2010) pineapple farmers in Ghana imitate a neighbor's fertilizer practices if the neighbor has been successful in the past
    - Migration flows are also an important source of information
  - Demand
    - Products need to fit local needs, as the examples below illustrate
- Example: Cooking stoves
  - Improving cooking stoves has major health benefits, as stoves are a leading source of indoor air pollution in low income countries
  - Technical challenge is increasing insulation to make them more efficient and use less fuel
  - But, also need to design stoves in ways that satisfy needs of local users
    - Portable
    - Durable
      - Makes materials a limiting factor – what works in the lab isn't necessarily best in the field
    - Cooking styles matter
      - One stove didn't work in Darfur because the local staple food required vigorous stirring
      - Another stove in India failed because it was designed to boil water, but did not get hot enough to make traditional Indian breads by frying
  - Note intensity of use is an issue here – new stoves must be desirable to be used

- Example: rice in Africa
  - The article examines why new seed technologies are diffusing slowly in Africa
    - These new seeds have higher yields and grow faster
    - However, they are used on only used on 5% of appropriate land
  - Barriers to diffusion
    - Need sustainable way to supply seeds
      - Over time, the seeds mix with local varieties and become less effective.
    - Individuals lack credit to buy seeds and fertilizer
    - Foreign aid is low
    - Infrastructure problems
      - Roads to market are poor
      - Storage facilities are poor
      - These problems lower income and thus demand for new seeds
    - A lack of crop insurance makes distributing seeds a high risk
    - Government corruption
  - Compare to India
    - New wheat varieties in the 1960s and 70s led to the Green Revolution.
    - What was different?
      - Seeds were supplied by a public seed company that bore the risks
      - India had better irrigation systems
      - India had better roads