The Evolution of Technology

Chapters 5 & 6

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Outline

Introduction

- Technological evolution cannot be fully explained with a biological (organic) metaphor.
- Technology recombines in ways that violate general biological rules.
- Technology evolution succumbs to pressures that cannot be fully explained in biological terms.

General Considerations

Observations:

- Immediate and potential uses of an invention are not always known.
- Inventions may not operate as expected.

Economic Constraints

Economic Determinism

Market pull, alone, drives selection and invention.

Important additional factors:

- Technological
- Social
- Cultural

The Waterwheel and the Steam Engine

If the waterwheel was such a useful development, why did it take so long to appear in use?

1. Lack of technological knowledge.
2. Greek and Roman attitudes toward nature, labor, and technology.
3. Lack of investment in technological improvements.

Economic Influence

While the stationary steam engine eventually replaced the waterwheel, it was delayed due to economic conditions which continued to favor the waterwheel.

The Mechanical Reaper

Pioneer of new business practices:

- Field trials
- Leveraged his competition
- Innovative advertising
- Financial incentives

Economic Feasibility

"No matter how effective and dedicated McCormic was as a promoter of his invention, its ultimate acceptance depended upon the machine's technological and economic feasibility."

The Supersonic Transport

Rejection

"The deliberate rejection of novelty serves as a corrective to those who think that technology moves smoothly from one success to another."

- Congress finally cut off all funding.
- Big government was acting on behalf of big business.
- Set the stage for public intervention in the future.

Military Necessity

Military contributions to new technology include jet propulsion, spacecraft, radar, computers, automated machine tools, and miniaturized electronics.

- Cost and ROI is secondary to military urgency
- Has had an effect on selection of technology
- May not be solely responsible for modern industry

Connected

"...[M]ilitary and civilian aspects of modern industry are intimately connected."

The Motor Truck

The truck predated World War I but did not see substantial growth until after it demonstrated its effectiveness during the war.

Military factors affecting the rise of the truck

- Demonstration of use in war (1916 war in Mexico and WWI)
- The Army's endorsement of the post-war highway plan

"World War I was the cradle in which the motor truck was nurtured."

Nuclear Power

- America's nuclear power industry would not be possible without the Manhattan Project.
- America leveraged technology and resources of allies to develop reactors for power generation.
- Early power reactors were more costly to operate than coal power plants.
- The Navy pioneered nuclear propulsion of ships (submarines and then carriers).
- The nuclear power industry would likely have collapsed if not for the pressure of the Cold War.

Outline

Technology and Chinese Culture

Cultural Paradox

Three inventions of Chinese origin, printing, gunpowder, and the magnetic compass, revolutionized literature, warfare, and navigation, respectively. They, however, had a disproportinate influence on Western culture and comparatively little impact on China.

Printing

Xylography

The Chinese invented movable type but xylography continued to dominate printing for centuries.

Movalbe type in the West influenced:

- emergence of modern consciousness
- secularization of printed work
- the Protestant revolt
- the rise of modern science
- the growth of education

Gunpowder

- Chinese culture favored swords over firearms.
- Gunpowder was used for ceremonies.
- Europeans won favorable trade arrangements with the help of large cannons mounted on ships.
- China had to decide to aggressively promote technological change or risk continued Western domination.

The Magnetic Compass

- Chinese discovered magnetic declination around 1080.
- Chinese used the compass to open new trade routes.
- Europeans used the compass to ensure naval superiority, which lasted for five centuries.

Chinese Cultural Stagnation

What accounts for the discoveries' lack of influence on Chinese culture?

1. Any technological artifact may disproportionately affect one country over another.
2. The way that Chinese applied these discoveries to the development of new technology may have been different than in the West.
3. The people evaluating the comparative impact are Western.

Fads and Fashions

- Fads are short-lived interests that influence the development of technology in unexpected and often ultimately unproductive directions.
- They still do, however, represent the current cultural values and ideologies.
- Many fads grow out of well-established industries or technologies.

Atmospheric Railway

Flaws:

- Engineering
  - Issues with valve seals especially due to weather (temperature)
  - Issues with failure in the line – one downed station downs the whole line
- Social
  - Train was only capable of traveling in one direction
  - Unreliability contributed to frequent delays in service.
- Business
  - Much more costly than conventional railway
  - Downtime led to poor service and lack of use

Nuclear Propulsion Vehicles

- Spacecraft
  - Open-ended reactor dumps nuclear waste directly into the atmosphere
  - Catastrophic result if there were a crash
  - Project Orion is analogous to strip-mining on a galactic scale
- Jet Airplane
  - Closed reactor would require materials not existent at the time.
  - Problem of shielding pilots and crew (not to mention passengers)
- Freighter
  - Not a complete technological failure
  - Was a complete economic failure
  - Failed to consider obvious business case

Discard and Extinction

Case Study: Oceania

Disappearance cannot be credited to natural disaster. There was some other selection at work.

Discarded Items:

- Bow & arrow
- Canoe
- Pottery

Alternative Paths

Assumption

"All too often it is assumed that the development of technology is rigidly unilinear, that at no point could other choices have been made."

Conclusion

If we can find examples of simple tools and technologies that have been designed differently but for the same purpose, then we can also expect to find examples of more complex modern technology that differs similarly.

Hand Tools

- Western saw
  - wider kerf
  - cuts on the push stroke
  - requires more material to make
- Draw saw
  - finer kerf
  - cuts on the pull stroke
  - requires less material to construct
  - may contain both rip and crosscut tooth patterns on the same tool

Block Printing: East and West

- Xylography versus typography
- Alphabet: Roughly 5000[1] vs. 26 characters
- Time to carve an entire page roughly equaled the time to typeset a folio sized page
- Emphasis on craftsmansip and artistry

[1] Today there are over 7000 characters but only 3500 are commonly used.

Railroads versus Canals

- Railroads are largely credited with the industrial and cultural expansion westward.
- Fogel argues that canals could just have well served the same purpose.
- Large scale farming pre-dated rail routes eastward.

Steam, Electric, and Gasoline Vehicles

In 1905 there was no clear advantage to any one type.

- Electirc
  - Quite and clean
  - Inexpensive to produce
  - Lacked sufficient range for rural use
  - Batteries were the weak link
- Steam
  - Lacked range due to the need for water
  - Mature technology
  - High torque at low RPM; no need for transmission
- Gasoline
  - Noisy and smelled bad.
  - Required highly refined fuel
  - Had plenty of power and range.
  - Was the eventual winner.

Conclusion

- Economic factors, alone, are necessary but insufficient to explain what drives technological invention and innovation.
- Military necessity is a key driver of technology.
- Military and commercial sectors are necessarily linked.
- Social and cultural values do much to shape the development and adoption of technology.