Bridging STP

Technology in historical perspective

Drivers of Technology:
- Productivity
  - Emergence of Mass Production, coordination
  - Infrastructure, increase ability to manage nature around us
- Nutrition (fire, fishing, agriculture)
  - Increased productivity in agriculture leads to urbanization, need less farmers
  - Food surplus leads to trade, collaboration, diversification
- Communication and Exchanges (paintings, paper, printing)
  - Enables collaboration and globalization
  - Really connection between people
- Materials (Semiconductors)
- Security and Comfort (Fire, building)
- Mobility (horses, Cars, ships)
  - Dictated how we build our cities
  - Also for human capital, Brain Drain
- Greed and Control (War, army)
  - A technological advantage allows to take over enemy

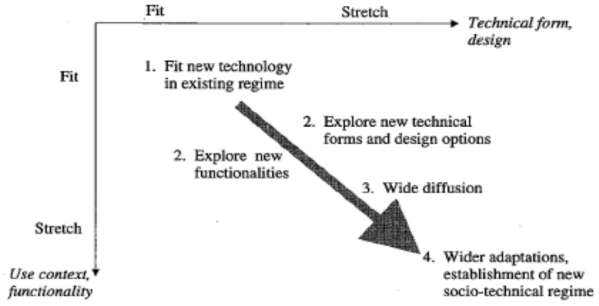
Technology —> Economic Development —> Societal Development

How Technology Emerges and Evolves

Three levels of Socio-Technical System
- Technological niches
  -
- Technological regimes
  - production process technologies
  - skills and procedures
  - Embedded in institutions and infrastructures
- Socio-technical landscapes
  - technology-external context. Not changeable by regime actors.

How can Technology fail?
- Poorly articulated demand
- Established technology has increasing returns to scale
- Poor connectivity among networks
- Legislative failures

Fit and Stretch



Limited Liability

- Gather capital for investment, attract investors —> Limited liability increase investments
  - In the case of financing through equity
- Economic competition as driver of spread of LL.

Sailships to Steamships

- Steamships linked with many other evolutions (Coevolution and Multi level)
  - Need for better communication
  - Need for predictability and regularity in shipping
  - increased market for passenger transport
  - Suez Canal

Horse carriages to Automobiles

- Multi level Perspective:
  - automobile linked up with users preferences and trend of suburbanization
  - Linked with cultural changes, experience of speed
- Coevolution of Technologies:
  - material innovations (paints)
  - borrowing from other sectors (electric starter)
  - new technologies as catalyst

Piston engine Aircrafts to Jetliners

- Coevolution of Technologies:
  - Incremental innovations from Material science (stronger alloys)
  - Cheaper and better fuels
- Diffusion as Trajectory of niche accumulation
  - Military domain as first niche
- Multi level Perspective
  - High speed trend
  - larger aircraft trend

Microelectronics, Computing, Internet

- Development primarily financed by the army (Turing, Enigma), not designed for public
- Size has decreased (hardware) and User experience increased (software)
- Helpers:
  - Material science (Silicon, transistor)
  - Computer and Softwares (Interface btw user and hardware)
  - Internet (More than one to one interaction) —> Standards
- 20 to 40 layers of software in a smartphone
- Benefit asymmetrical between developed and emerging countries
- Social Impact
  - Overcoming distances
  - Online life organization
  - Big Data

- Universality of the Internet, **fragmentation**
  - Different Apps / Languages
  - Censorship
  - Right to be forgotten?
  - Sometimes wanted (Firewalls for example)

- Internet Governance
  - Proxy for State power (Colloquium)
  - **Back doors** problem: can weaken internet security
  - **Data Localization**?
    - Could promote fragmentation rather than universality
  - DNS alteration

Food Production: The Green Revolution

- Large scale farming, increased productivity
- After industrial revolution
- Profited from progress in chemistry
- Help of Tractors, Trucks, Aircrafts, Irrigation systems (multi level and coevolution)
- Special machines (build only for farming, for ex harvesters)
- Fertilizers, pesticides
  - Health effects (irritation, danger from pesticides)
  - Environmental effects (water and soil pollution, reducing biodiversity)
  - Economic effects (higher productivity)
- GMOs
  - progress in biotechnology
  - reduces need for pesticide, increase yields, increase farmer's profits
  - danger not clear, safe?
  - IP rights problem
  - Media influences perception —> No matter if risk or not, if public thinks risky, act as if
  - Risk perception varies across population, countries (US less problematic)
  - Lobby influence (high economic perspective)
  - Increase resilience of the food system

Difference US, UE
Precautionary principle (UE)
- Unless we know it is safe, don't use it
- Ban upfront if you think is dangerous

Sound science (US)
- Until proof it is harmful, allow it
- Tort law in US, allows higher payoffs to potential victims —> incentive for US to trust more the product of a company because of the high risks
- Put big sanctions if problem arises
- Proof before ban culture (evidence-based policy making)
- Labelling problem, why no GMO label in the US?
  - economic: labelling is expensive (increase product costs)
  - risk perception, consumer behavior (with label you might change GMO perception, no incentive to do it)

Life Sciences Pharmaceuticals and Diagnostic Technology

Enablers of today's life science
- calibration
  - body temperature, blood pressure
  - precise measurements
- Small scale measurement and visualization
  - microscopes, fluorescence
- Improvement on instrumentation
- Transition from mechanical parts to electronic instrumentation

Problems in pharmaceutical industry

- Development cycle very long
- Less popular diseases tend to be more founded by public money
- R&D structure —> high pill price —> development countries don't have possibility to buy it
- Patents:
  - Pro:
    - necessary for internalization of positive externality (spillover of knowledge)
    - temporal monopoly
    - protect the incentive for innovation
  - Against:
    - Prevent positive externalities
    - High cost of medicaments
    - Restrict innovation
  - what should be allowed to be patented? living organisms? Where do you draw the line

Pharma industry follows technology push model
- Once patent expired, the generics come (lower cost, way less R&D)
- Biotech firms involved now in taking some part of the innovation process

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Primary Fuels, Renewables, Networks

- Nuclear Fuel
  - Enabled by war driven technology process
  - safe dumping of radioactive waste difficult
  - risk of meltdown
- Wind turbines
  - cost of energy reduces with larger turbines
  - enabled thanks to (glass fibre, material science for blades, rotor)
- Solar PV
  - semiconductor, material science
  - transistor as driver
- Renewable drawbacks
  - highly dynamic production, not great for baseload
  - strategy: China produces 60% of PV cells
  - public acceptance **NIMBY** (Not In My BackYard)
- Futur of Oil, Oil Peak
  - Production curve reaching a maximum
  - Many uncertainties in predicting oil production (wells to discover, disruptive process)
- Feed In Tariff for Energy Transition
  - FiT didn't create economic stimulus in Germany, 60% of PV from China, created maintenance works in Germany though
  - Oversupply of electricity and falling prices
  - No major incentive to phase out Coal as prices low and green thanks to renewables
  - Price increasing effect in the market, too many PVs, too much energy in the system
- Energy Storage:
  - Hydro pump in Switzerland by far the most efficient, buy cheap energy, when need open valves
- Coevolution of energy systems and other societal subsystems (transportation, housing, industry)

Automation Self Driving cars, Trains and Drones

Automation
- Getting the human out of the loop
- Always coupled with other innovations,
- Industrial / Transportation / Automation / Agriculture
- Increases efficiency, need for high skilled workers
- Improves quality (humans make a lot of mistakes)
- Increases safety

Automated Transportation
- Good for environmental sustainability
- Traffic efficiency
- Safety and higher productivity
- Challenges:
  - Big Data, communication between cars, network availability, data storage, system resiliency?
  - Public and Private transportation merging together
  - Synergy of automated and non-automated vehicles
  - Liability and Privacy (misuse of data)

Military Automation
- Remotely controlled devices
- Don't care about liability, sovereign state always liable in military applications
- Drivers:
  - Reduced Manpower
  - Superiority of military force

Social Implications of Automation
- Employment vs Productivity, productivity up and employment not as much, gap
- decoupling economy from humans
- Reduces blue collar jobs and more white collar jobs
- Shift in employment patterns

Drones
- Military (almost no regulation), military doesn't care about cost efficiency only about technological advance
- Commercial (Agriculture, Public Safety, Photography)
- Entertainment (Wide demand created)
- Liability Issues
- Enablers:
  - GPS, Sensors, Batteries, Motors
- Many legal hurdles. A drone can be used as a weapon. **Safety concerns. Privacy issues?**
- Now: Need human operator within line of sight of every single drone in US
- Need regulation change:
  - regulations very fragmented
  - in UE, below 150kg regulated by individual member states
  - Flight authorization information
  - Governments have come in relatively late
  - Push and Pull considerations: gvmt does too much stop innovation, too few creates mess
  - Regulations at many levels State / International
- Regulations
  - Licenses like cars
  - No fly zones
  - Restrict usage
  - Backdoor
  - Private insurance scheme for liability

Self Driving Cars
  - still need for incremental technology for example sensors
  - Already some autonomous features, parking, cruise, highway driving assistant
  - Follow incremental approach
  - Regulation:
    - different level of automation from 0 (no automation) to 4 (full automation)
    - Trade off privacy liability, also have to consider efficiency —> Evaluate with CBA
    - Shift liability toward manufacturer
  - Impact on
    - Freedom
    - Privacy
    - Liability

- Discretionary vehicles (give user choice to when AV when manual) —> High Freedom, high liability?
- Nondiscretionary vehicles (almost 100% autonomous from driver) —> Low Freedom, Low liability?
- Communicative vehicles —> Low privacy?
- Uncommunicative vehicles —> High privacy?
- Market share liability
- Infrastructure issue, who pays for the upfront investment?

Big Data and Communication

- Why don't we have a bigger IoT today?
  - Sensors too expensive
  - Communication standards too stringent
  - social acceptance not there yet
  - Energy consumption
- Big Data
  - Quantity of Data is not new, ability to treat it is new
  - Enabler: Algorithms, improved statistical methods
  - Application: Predicting where crime will happen?
  - Accessibility of Data? —> Who can use it, under which conditions?
  - Make big corporations more comfortable with sharing the data, with policy
  - Still need to collect data for a purpose
  - Spread explained by persons who vote (wealthier) have less to loose than others in privacy intrusion and use of big data
  - **+** Better productivity, Good for research, less waste and higher profitability
  - **-** Problem of consent, hacking, resiliency,
  - Players are Business, Government and Consumers and Business tend to overlook wish of privacy of consumer
  - Lawsuits in order to start change?
- Centralized top down control of data:
  - Problems:
    - Failure to address local needs
    - Undermine collective intelligence
    - Filter bible
    - Reduction of pluralism
    - Information Asymmetry
- Digital Democracy
  - Big Data enabling us to transform society organization

Military and Security Issues

- Warfare always been a place where technological advantage played a huge role
- Military technology as enabler of foreign policy:
  - Technology gives you advantage / control over others
  - Big threat if treaties not respected for example
- War effective « producer of new technologies »
- Military don't have time horizon of companies / of CEOs who stay 4-5 years in one Company. Problem with CEOs is that they incur the cost but don't benefit themselves from the benefits, the next CEO will. —> For long term projects

Nuclear Proliferation

- Pressure Communism Capitalism, Mutual Suspicion
- International call for regime change might be part of the problem. Feel threaten, arm.

Arms race in Space:
- Need for Infrastructure brings huge problems
- Destroy other's satellites with laser or small object or with satellite
- Weaponization of space
- Regulatory framework far behind (Monitoring very hard)
- Dual Use Problem, satellite not designed as weapon can be used as one

Information Warfare
- Shift from weapons to information warfare
- Enabled by easy communication Internet
- Disinformation, Espionage (not only military by the way)
- Changing your enemy's decision-making process, change information

Arms races
- Explained by prisoner's dilemma, dominant strategy is to arm
- Personalist dictatorial leaders bigger tendency to seek nuclear proliferation
- Nuclear acquisition may enhance international prestige of the state

Arms Control and Disarmament
- NPT, countries which have nuclear can keep it but neither sell it nor provide it
- NPT, Peaceful nuclear energy
- NPT, Countries promise to disarm in future (good faith, no date attached)

Cyber Governance
- Barriers to entry low, offense cheaper than defense
- Cyberspace is a public good or global commons
- Lot of different actors, loose coupling between them
- Lot of fragmentation

Climate Change, Geoengineering, Fusion

Future Drivers
- Technology is driven by public emotions
- Public emotions driven by public perception
  - Not important if a threat is real or not, as long as perceived so
- Pollution
- Scarcity of Resources
- Over population
- Limited food production capacity
- Limiting Factor: Energy

Solve Energy Problem with Nuclear Fusion:
- Advantages:
  - Components easy to have (Deuterium from electrolysis)
  - New technologies are affordable and available to help build fusion —> Magnets from MRI, Lasers
  - Get Oil and Gas out of the mix
  - Possible for Base load supply
  - Reliable
  - Waste is harmless and in small quantity
- Opponents:
  - Stakeholders in Gas and Oil (Lobby)
  - Green parties, say money diverts from Renewable
- Dangers
  - International conflict, who controls the energy first? Who has the heavy water accelerators?
  - Who decides the price of fusion energy?
- Problems:

    - Not enough R&D funding, costly to develop
    - requires international cooperation

Geoengineering
- Dangers
    - Unknown long term consequence —> Modification of plant life, temperature redistribution
    - Unilateral action of one player
    - Shift risk from one place on the earth to another
- Ethic question: Should we change the planet instead of getting the emissions down?
- Reflect some of the sun's radiation
- In case of critical situation, we could imagine such an intervention, otherwise no.
- Also: No consensus on what temperature we should seek, different countries have different wishes.
- Problems:
    - Not enough research
    - No political realization

Climate Change
- Why problem so difficult solving?
    - Many different stakeholders and interests
    - Fossil fuel is practical, portable, convenient
    - Collective Action issue —> International free rider issue
    - Short Term cost of changing —> Scare Tactics as strategy
    - Long term benefit of changing —> Uncertainty about Benefit
- Problem is that it is easier to motivate acting locally, constructing digues, positive externality only for yourself. Insurance against effects but not contributing to avoiding problem.
- Mitigation
    - GHG reductions
    - GHG removal —> Problem, might take away the incentive to reduce GHG emissions, also cost and safety problem for storage

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Information, Communication, Robotics, Biology, Nanotechnology

Drivers of Science and Technological Growth
- Safety (Health, War, Conflict)
- Efficiency (Productivity)
- Mobility (Energy, Information)
- Quality of life
- Knowledge and curiosity
- Regulations and Policy

Merger of Health Science, IT, AI and Nanotech
- Health systems
- Surgery
- Policy Implications? —> Liability, who liable if things go wrong?