# Lec 03:Economics of Value Creation by Leveraging Technology

EEE 452: Engineering Economics and Management

*…how are ideas in leveraging EEC technology possibilities*

*for getting jobs done better being shaped in a competitive*

*market into eocnomic value or waste…*

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# Production Function:

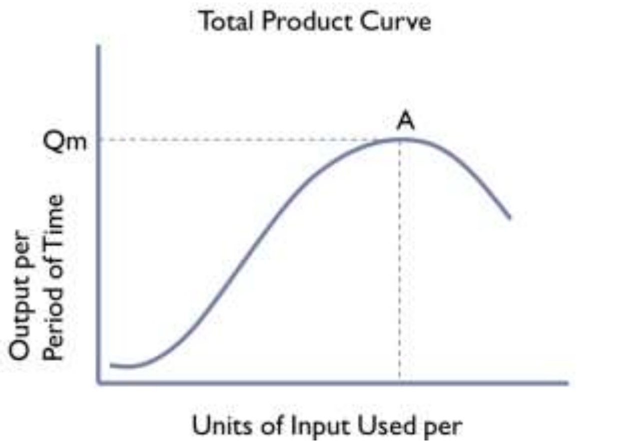
**Cobb-Douglas:** In economics, a production function gives the relation between quantities of physical inputs and quantities of output of goods.

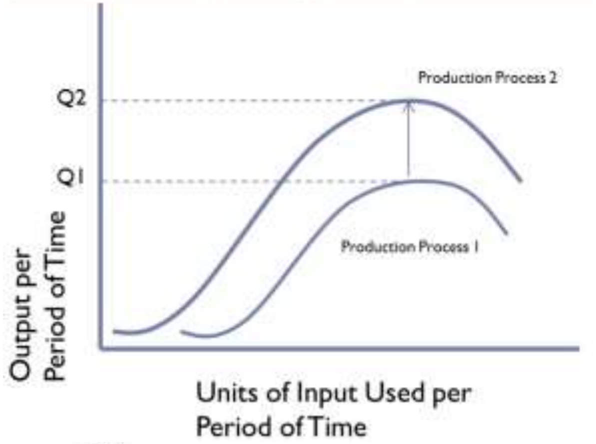
Based on the statistical evidence gathered during 1927–1947, Cobb–Douglas production function was derived as a function of labor (L) and capital (K), as shown in Eq. 1.

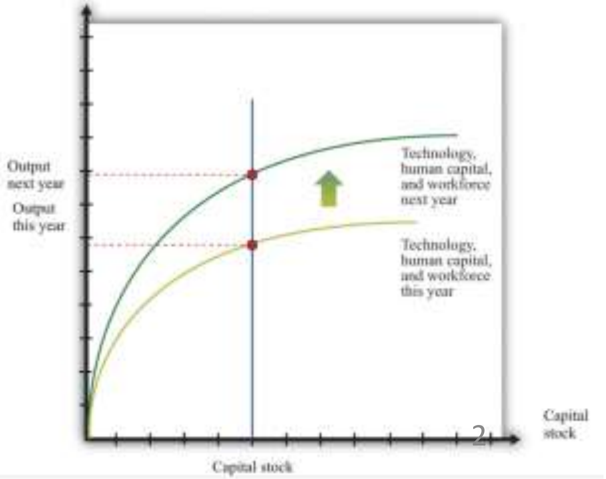
In its elaboration, total factor productivity (TFP, A') was conceived to include the role of technology (knowledge, science, technology, ideas), giving the impression that as if there is a linear correlation between ideas and economic output.

$$f(L, K) = Y = A'L^{\alpha}K^{\beta} \tag{1}$$

- Physical capital—machines, production facilities, and so forth that are used in production; role of machine has been increasing
- Labor—the number of hours that are worked in the entire economy
- Human capital—skills and education embodied in the workforce of the economy; however, scope of human capital in production has been falling.
- Knowledge—basic scientific knowledge, and blueprints that describe the available production processes; knowledge is being automated as machine capability
- Perceived value includes: functional value, monetary value, social value, and psychological value.



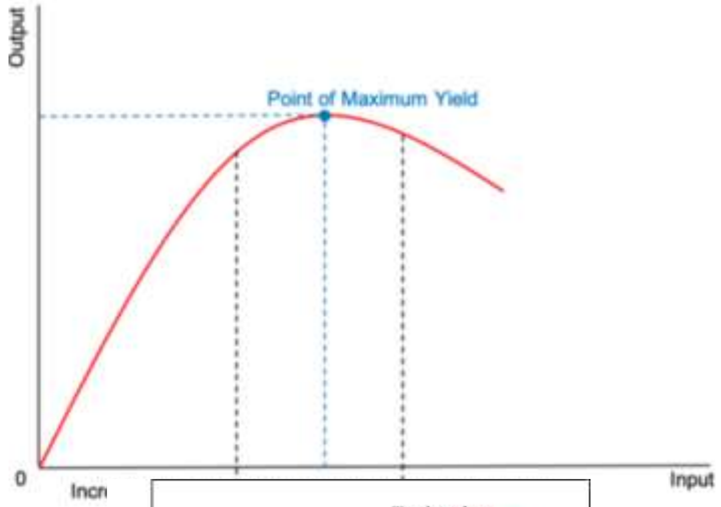



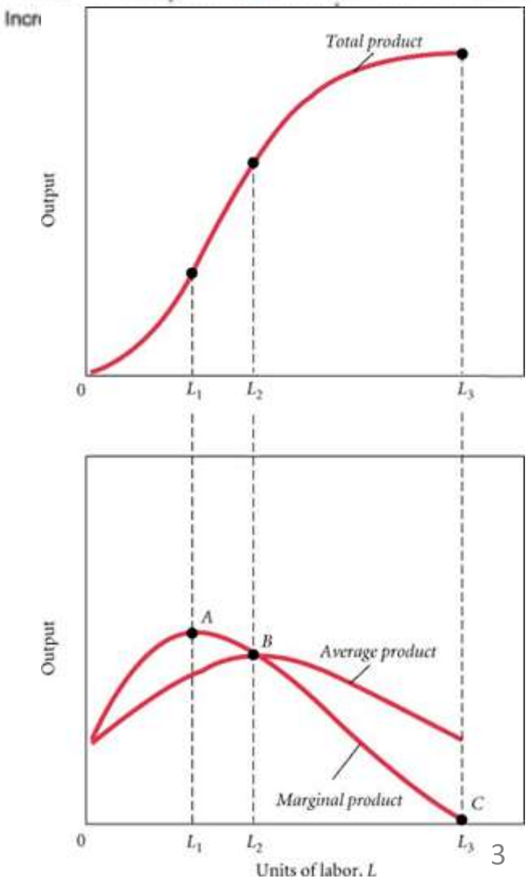
# Production Function--diminishing returns

- In economics, diminishing returns is the decrease in marginal (incremental) output of a production process as the amount of a single factor of production is incrementally increased, holding all other factors of production equal.
- A common example of diminishing returns is choosing to hire more people on a factory floor to alter current manufacturing and production capabilities. Given that the capital on the floor (e.g. manufacturing machines, pre-existing technology, warehouses etc.) is held constant, increasing from one employee to two employees is, theoretically, going to more than double production possibilities and this is called increasing returns.
- If we now employ 50 people, at some point increasing the number of employees by two percent (from 50 to 51 employees) would increase output by 2 percent and this is called constant returns.
- However if we look further along the production curve to for example 100 employees, floor space is likely getting crowded, there is too many people operating the machines and in the building and workers are getting in each other's way. Increasing the number of employees by 2 percent (from 100 to 102 employees) would increase output by less than 2 percent and this is called "diminishing returns”

**Total product** is the total amount produced per set of resources, **average product** is the average cost per unit produced per set of resources, and **marginal product** is the cost for the very next unit to be produced in resources.

- In technology business, however,  there are possibilities of having  constant or exponential return to scale.



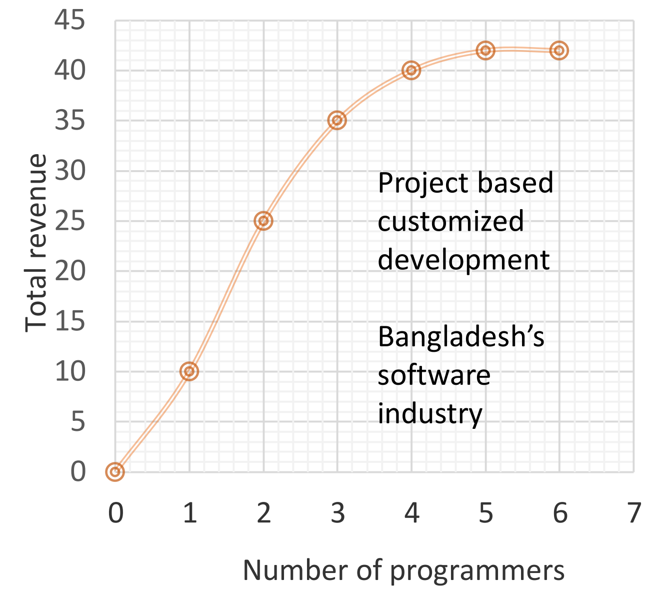
## Production Function—software industry

### Customized software production:

•Due to complementary role—there is a bit of signature of exponential growth at the bottom.

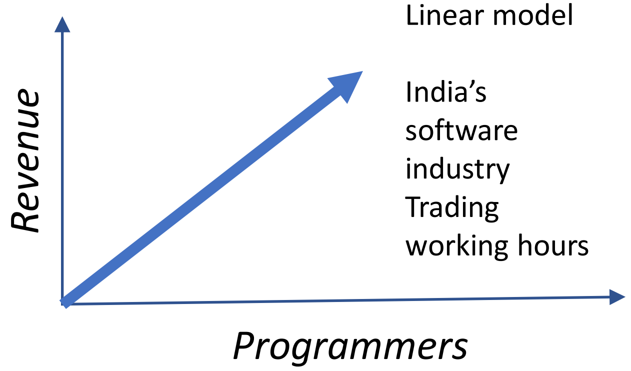
•As a firm keeps adding more professional for performing same tasks like coding or requirement capturing, and pursuing strict policy of job division and specialization, total revenue stops growing linearly. Here are few causes: i. waiting time due to interdependence, ii. rework due to introduction of errors for miscommunication, iii. weaker reusability due to knowledge gap.

•To overcome it, focus on creating optimum work load, standardization, process maturity and so on. This is the underlying cause of slow growth and small size of software firms in Bangladesh.



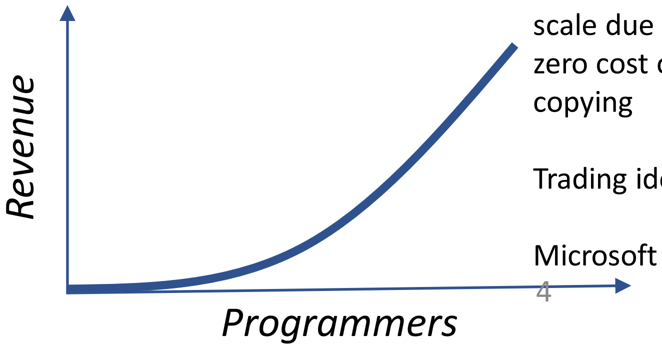

### Work for hire—linear model:

Per-person billing—India's success story. Growth is only limited by demand and supply of programmers—huge scale advantage. Due to it, Bangladesh could not take a share of it.




### Trading software asset: zero cost of copying software

For increasing scale advantage, focus on reusability for selling the same software assets to a growing number of customers. It demands R&D investment for creating willingness to pay among growing number of customers.



# Short and Long Run Decisions:

**Short-Run:** All production in real time occurs in the short-run. The decisions made by businesses tend to be focused on operational aspects, which is defined as specific decisions made to manage the day to day activities in the company. Businesses are limited by many things including staff, facilities, skill-sets, and technology. Hence, decisions reflect ways to achieve maximum output given these restrictions. Often, operation management software applications play vital role in short run decisions.

**Long-run:** The long run refers to a period of time where all factors of production and costs are variable. Over the long run, a firm will search for the production technology that allows it to produce the desired level of output at the lowest cost.

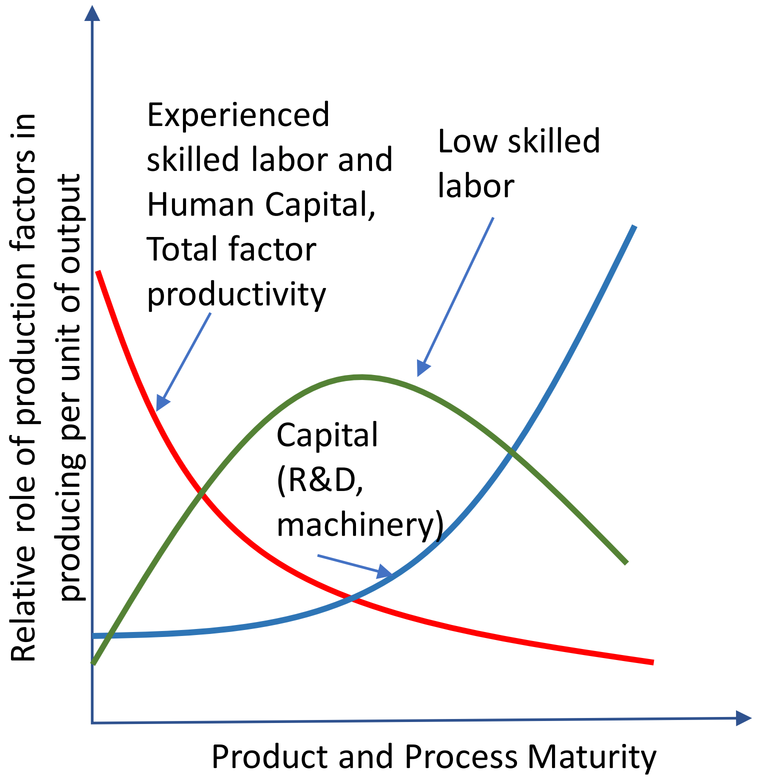
Change of technology cores of both products and processes are long-run decisions. The implementation of such decisions is fraught with pervasive uncertainties. Furthermore, it demands huge investment and takes a long time to generate profitable revenue from such decisions.

For example, the change of display technology core of TV was a long run decision. Similarly, migration from 5nm to 2nm semiconductor processing technology is a long-run decision. Often, it requires significant technology development to pursue long-run decisions. Hence, business graduates are not capable enough by themselves for dealing with long run decisions.

Change of business model, like moving from trading working hours to ideas in software business, is a long run decision.

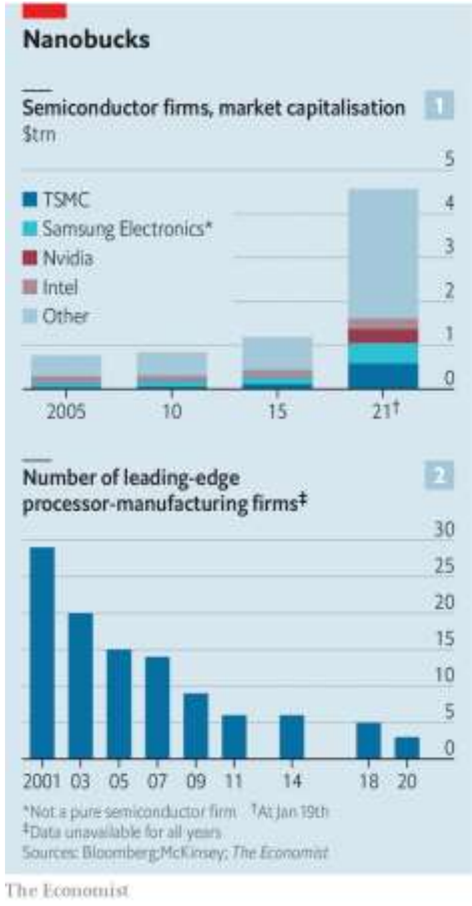
# Changing Roles of Production Factors:

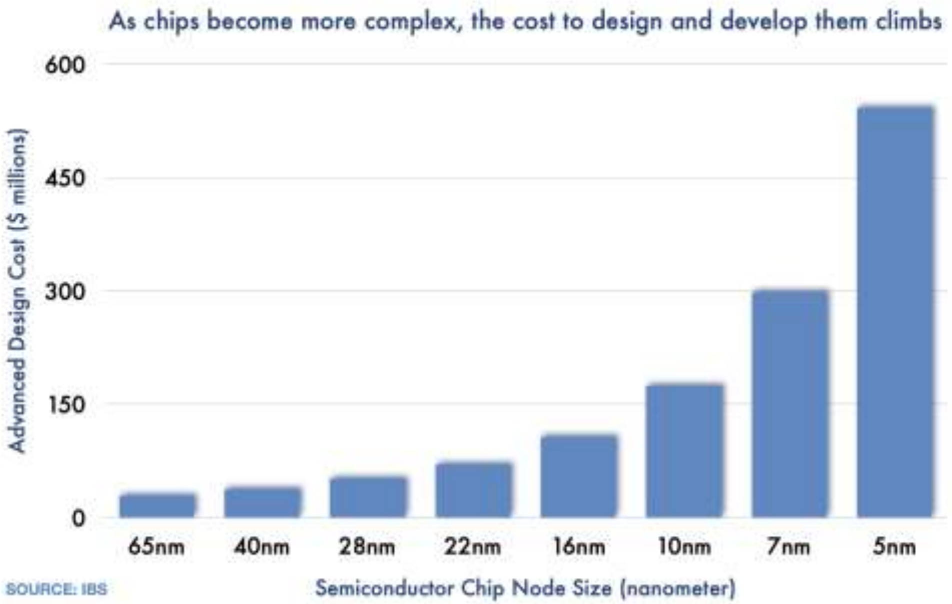
- With the process maturity, demand for tacit capability keeps falling—as tacit role is reduced through jobs division and codification. Codification leads to rule set—amenable to automation.
- Process maturity keeps automating codified knowledge and skill, resulting in lowering demand for human capital in production.
- Job division, rule development, and automation lead to increasing demand for low skilled work force in production.
- Further advancement of process maturity leads to reducing low skilled demand too.
- On the other hand, the role of capital machinery keeps increasing.
- The dynamic relation between the demand for experience, codified knowledge and skill,  low skilled labor, and capital machinery keeps changing.
- Maturity of product also have similar implications on production factors.

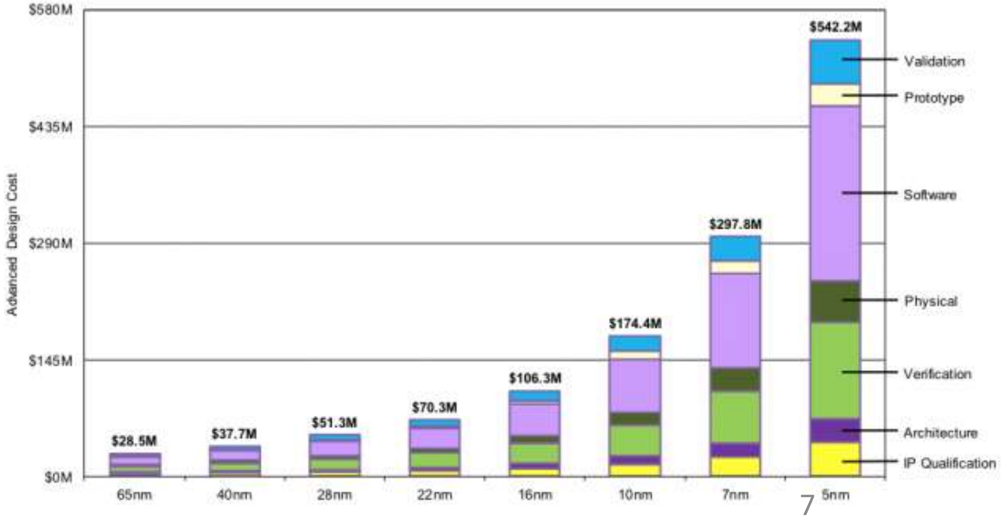


# Increasing Role of Capital and Monopolization: Semiconductor

- Products and also process start improving due to the flow of ideas. These ideas are vital for offering higher quality at decreasing per unit (transistor or pixel) cost. But it keeps increasing the upfront cost.
- Ideas are integrated in both products and processes—increasingly, in the form of software.
- Hence, there has been growing capital expenditure in the form of advanced machines and R&D cost. As a result, economies of scale advantage keeps growing.
- For example a 5nm plant cost USD15 billion, 25% higher than 7nm plant requiring $12billion.
- However, to take advantage of it, sales volume should keep growing proportionately—for reaching the minimum efficient scale.
- Hence, larger firms have been marginalizing smaller ones into extinction—giving rise of monopolization.



# Solow Growth Model:

- Prof Solow observed that the sum is smaller than the total growth upon adding growth contributed by capital and labor. He termed this difference as Solow residual and attributed it to the contribution made by science, technology, and ideas.
- The Solow residual, SR(t), is the portion of an economy's output growth that cannot be attributed to the accumulation of capital and labor, as shown in Eq. 2.
- However, how it contributes is not explained. It was considered as an exogenous or external factor, giving the impression that the accumulation of science, technology, and idea stock in a firm or within a country will lead to proportionate economic growth.
- Role of technology is an exogenous factor--**attributable to an agent or organism outside an organization or firm.**

$$SR(t) = \frac{\frac{\partial Y}{\partial t}}{Y} - \left( \alpha \frac{\frac{\partial K}{\partial t}}{K(t)} + (1-\alpha) \frac{\frac{\partial L}{\partial t}}{L(t)} \right) \qquad (2)$$

$$\frac{dY}{Y} = \alpha \frac{dK}{K} + (1-\alpha)\frac{dL}{L} + \frac{dA}{A} \qquad \ldots (4)$$

| Growth in output | = | contribution of capital | + | contribution of labour | growth in TFP |
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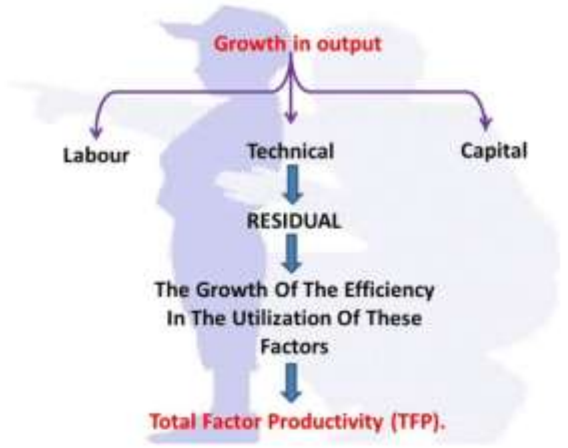



TFP (total factor productivity) becomes the portion of growth in output not explained by growth in traditionally measured inputs of labour and capital used in production.

Technology growth and efficiency are regarded as two of the biggest sub-sections of Total Factor Productivity.

# Human Capital:

- In the 1970s, a body of knowledge started growing with the argument that economic growth stems from human capital (H), in addition to labor and physical capital, leading to the following analytical construct, Eq.3.
- As a result, development thinkers started emphasizing higher education to increase the supply of knowledge stock. Hence, there has been growing investment for higher education, particularly in science and engineering, hoping that increasing human capital stock will increase prosperity.
- Therefore, less developed countries will succeed in having sustained growth out for saving from labor and making that investment for human capital development.

$$Y=F(K, L,H) \qquad (3)$$

However, due to growing automation of codified knowledge and skill in both products and processes, the role of human capital in production has been falling.

On the other hand, role of human capital in R&D has been growing, as it has been increasingly getting tougher to generate knowledge for producing ideas to improve quality and reduce cost.

Countries relying on importing ideas (technology) in the form of capital machinery and design of products, and relying on labor for local value addition are experiencing growing unemployment in university graduates.

On the other hand, countries depending on ideas for creating economic value have been demanding growing number of high caliber graduates for knowledge generation to produce ideas.

There has been no natural correlation between H and Y.

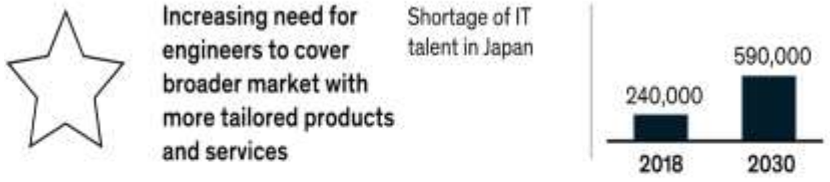
Specifically, the number of Americans engaged in R&D has jumped by more than twentyfold since 1930 while their collective productivity has dropped by a factor of 41.

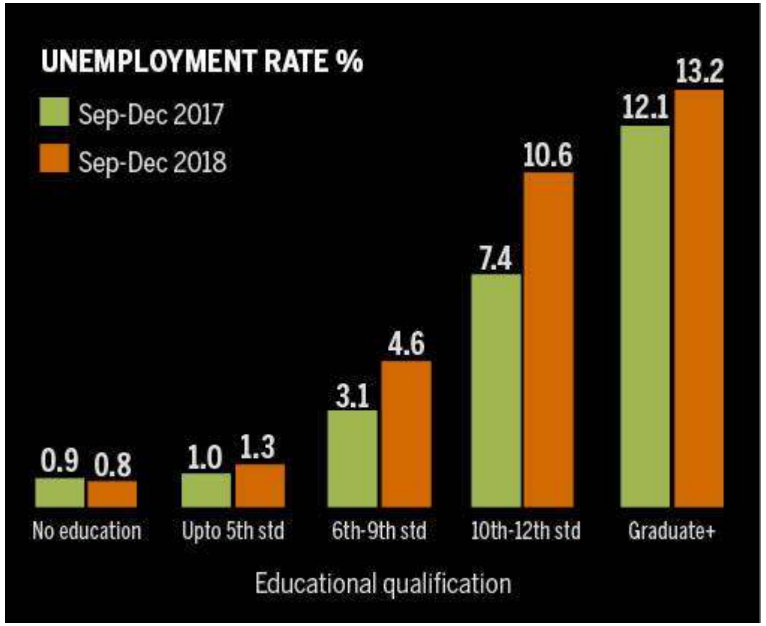
"It's getting harder and harder to make new ideas, and the economy is more or less compensating for that," Bloom says. "The only way we've been able to roughly maintain growth is to throw more and more scientists at it."


The Economist

# Challenges in Creating Economic Value from Human Capital

- Knowledge demand in production has been falling, but demand for knowledge in idea production has been increasing.
- But the challenge in producing economic value has been growing due to growing hurdle in making entry in reinvention race by changing technology core or outperforming competitors in sustaining innovation.
- On the other hand, linear model of innovation is extremely risky and lengthy in reaching profit.
- As high as 85% engineering graduates in India are failing to find engineering jobs.
- Questionable natural correlation between engineering education and economic value creation.
- It appears that role of Human capital, particulalry STEM graduates, has country level polarization effect.
- Incraesing public fund for R&D faces challenegs in truning R&D outputs into economic value. For example, the success of convention of India's growing publications into economic value is not beyond questions.



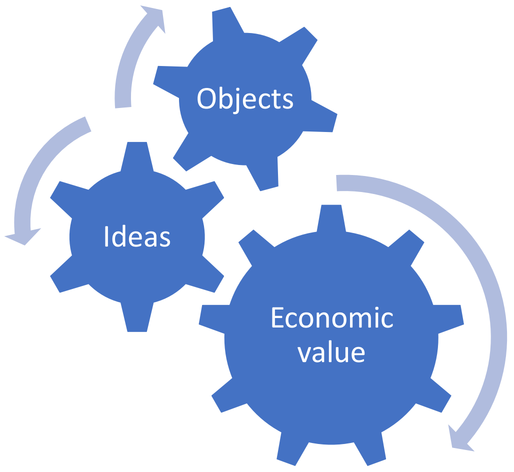



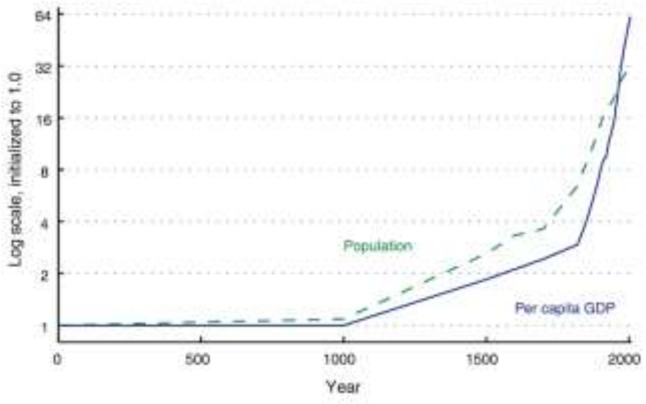

India

https://www.mckinsey.com/business-functions/operations/our-insights/a-new-era-for-industrial-rnd-in-japan

# Ideas and Objects:

- To better understand the role of human capital in economic output, Paul Romer argued that human capital is distilled in the form of ideas (Jones, 2019), whether as features of capital machinery or a recipe of mixing ingredients.
- Although it takes an initial investment in producing ideas, the marginal cost of implementing them in each unit of output (product) is negligible.
- He also promoted a unique characteristic of ideas: non-rivalry. It means that the same idea could be used simultaneously by many actors.
- Hence, economic value creation out of ideas appears to be unlimited. But unlike ideas, all other inputs used in producing economic value like labor, land, raw materials, or factory building are riva as the same input could not be used simultaneously by multiple actors.
- Hence, he articulated economic output function as ideas (A, non-rivalry input) and objects (X, rival input), as shown in Eq. 4, giving the impression that there is a natural correction between Y and A.
- He also emphasized that ideas stem from endogenous or deliberate internal activities instead of external or exogenous factors.
- Furthermore, he stresses the necessity of partial excludability for creating economic incentives for the production and exploitation of ideas.



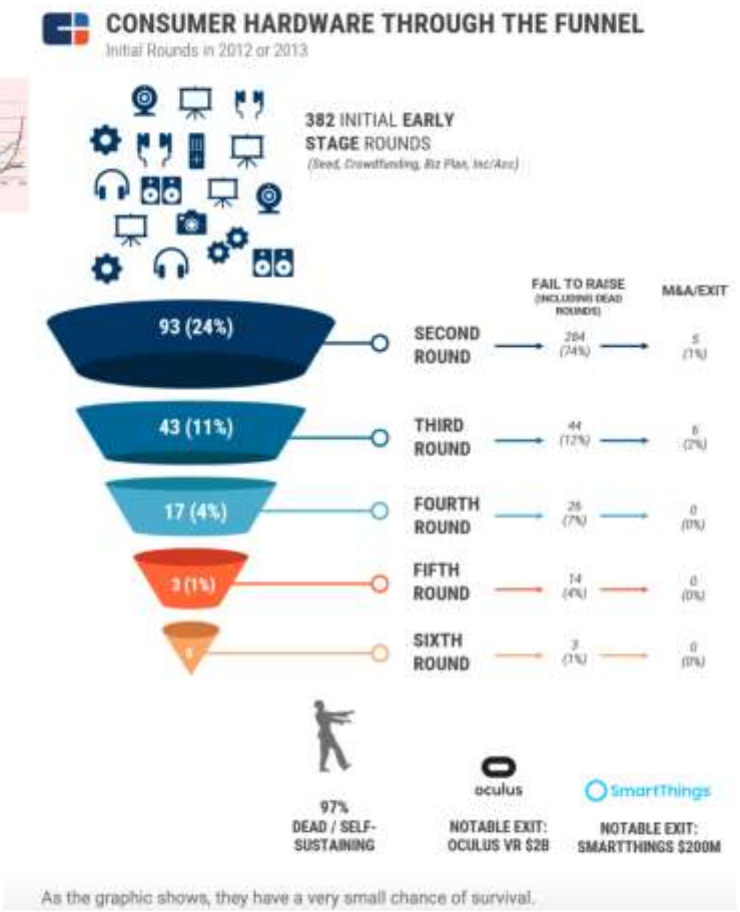

$$Y=F(A, X) \quad (4)$$

# No Natural Correlation Between Ideas and Economic Value: Decision making challenges

- Dynamic and unpredictable role of A on economic output demands decision-making capability: There is a need for understanding the dynamics of economic value creation out of ideas in a competitive market.
- This understanding of the dynamics (D) is vital for making decisions (D) for creating economic value out of ideas.
- Hence, the analytical construct as shown in Eq. 5 is not sufficient, which could be updated by including decision variable D (proposed) as shown in Eq. 7.
- In fact, D will provide guidance about what ideas should be produced and how those should be converted into economic value.

$$Y=F(K, L, H, A, D) \tag{7}$$

- Therefore, the investment should be made for increasing the understanding of technology innovation dynamics for improving decision (D) making role for creating economic value out of ideas (A).




# Leveraging of Ideas:

The supply of ideas and their utilization can take place in more than one stream. In addition to pursuing big ideas, we should also focus on the invention of millions of little ideas (for example, better ways to sew a shirt or grow, harvest, and package fruits), that make persistent economic growth possible. Some of the major sources are:

1. GRASSROOTS LEVEL INNOVATION
2. CORPORATE OPERATIONAL INNOVATION
3. PUBLIC SERVICE INNOVATION
4. PRODUCTION PROCESS ENHANCEMENT AND CAPITAL MACHINERY INNOVATION THROUGH IDEAS
5. INCREMENTAL ADVANCEMENT OF PRODUCT
6. REINVENTION FOR LATERAL ENTRY IN THE INNOVATION RACE OF EXISTING PRODUCTS
7. STARTUPS AND DISRUPTIVE INNOVATION
8. SCIENTIFIC DISCOVERY AND TECHNOLOGY INVENTION

Instead of looking into ideas as an external factor and public good, there should be close attention to the role of ideas and explicit measures for increasing the local supply of ideas and their utilisation in products and processes. Although there has been an acknowledgment of ideas as an endogenous factor in contemporary thinking of economics, the economic value out of ideas not only depends on the local supply of ideas. Profiting from ideas in the globally competitive market economy is highly uncertain and also volatile.

**https://thefinancialexpress.com.bd/views/views/ideas-to-fuel-sustained-growth-in-the-post-ldc-era-1616427729**

# Episodic Market Value of Ideas (inventions):

- Inventions don't keep growing by following a continuous path out of the flow of ideas from human capital, and R&D investment.
- Irrespective of the greatness, every invention shows up in primitive form, having little or no economic value creation potential, and keeps growing through a flow of ideas.
- Surprisingly, they have not been growing following a continuous path.
- Instead, they keep growing for a specific interval of time through the cumulative effect of incremental ideas---followed by disintegration and the rise of the next wave, as shown in Fig. 1.
- Innovation in reality appears to have an episodic model in which period of conventual continuity through incremental innovations, where there is cumulative progress, is followed by interruption creating period of revolutionary innovation or creative destruction.
- Hence, this episodic nature of the inventions' progression is vital to investigate to draw lessons for leveraging ideas for economic prosperity.
- It appears that there are three distinct phases: i. The formation, either through invention or regeneration (reinvention), ii. Metamorphosis, and iii. Disintegration.
- Through these three phases, inventions have been evolving in offering us increasing value from natural resources and labor. Prof. Schumpeter observed it as a process of creative destruction (Schumpeter, J., 1942).

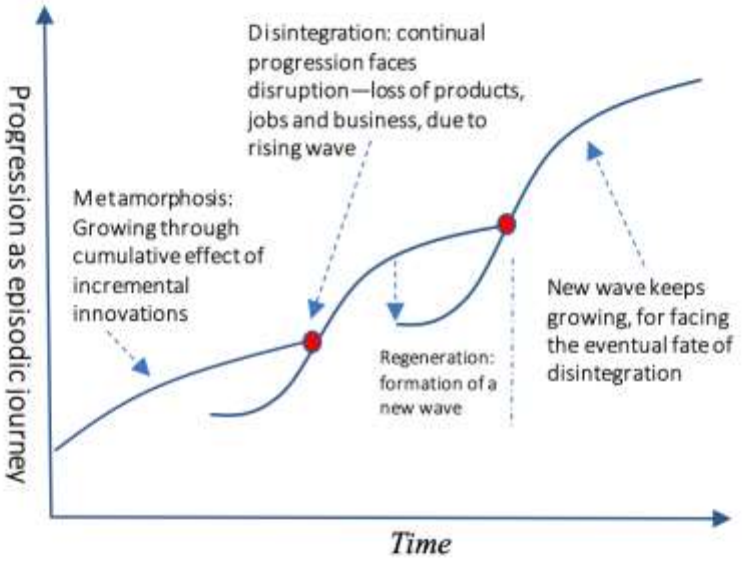
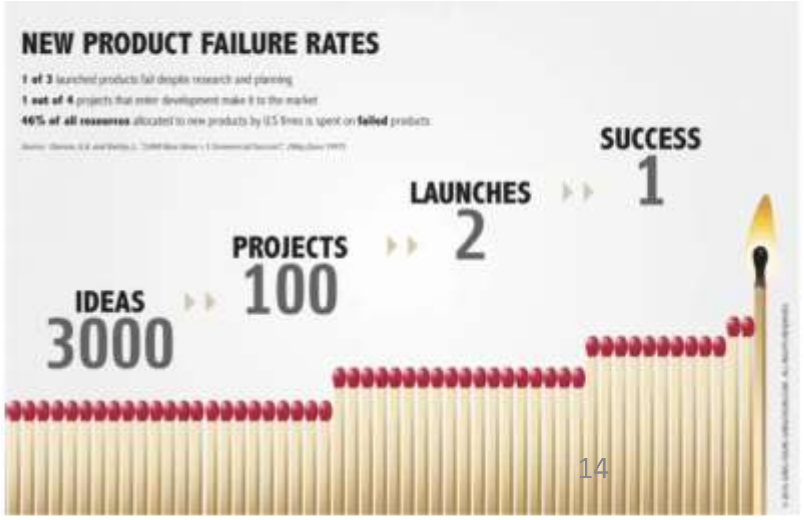



Figure 1: Episodic model of progression of inventions



# Inappropriate Belief About Ideas: leading to wrong culture and decisions

**Innovation is a solo activity:** Consistent with our tendency to think of innovation solely in terms of mind-blowing new inventions, we often think of innovators as genius, oddballs with wild ideas and wilder hair. In reality, innovation requires systematic engagement of a group of people (hundreds or thousands) even over decades for turning ideas into profit.

**Innovation can't be taught:** It's not like teaching math and accounting—or coaching for developing business plan. Teaching innovative thinking isn't like teaching Math or French—it's more a matter of teaching people how to harness their existing natural curiosity in order to unleash their innate capacity for innovation. Furthermore, helping them to comprehend innovation dynamics within applicable model so that likelihood of unfolding future could be predicted.

**Innovation isn't for everyone:** When kids see something exciting first time , they almost immediately start asking questions and dreaming up their own innovations. Innovative thinking is contagious. It's a bug that anyone can catch. Challenge is to help them finding discipline in unfolding innovation dynamics, so that they are not thrown in wild ideation like a popcorn machine.

**Innovation is about the newest thing:**—newest thing begins the journey in primitive from, and keep progressing in an incremental manner, even over decades and centuries.

**Change is always good:** not always—synchronization is a key.

**You can't force innovation:** —for responding to competition, consistent innovation is must. We cannot rely on sudden creative spark.

**Innovation is top-down:**—but many ideas originate from operation.

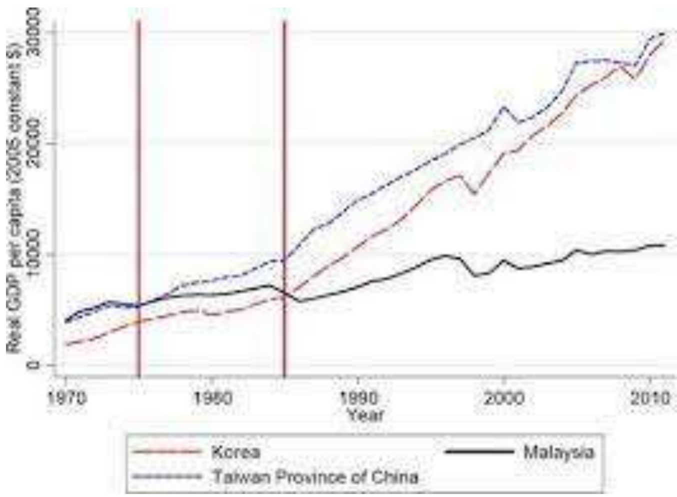
# Creating Economic Value out of Human Capital and Ideas:

**Idea users and producers :** Technology (ideas) could be used for personal consumption or as capital machinery. Being technology users, we can create economic value as it produces consumer surplus for the the consumption. Furthermore, the use of improved technologies increases the quality and reduction of cost of production. It also creates the demand for labor and natural resources. Hence, one of the development thoughts has been to save from trade of labor and natural resources and import technologies.

However, the role of technology in reducing the demand for labor and also certain natural resources poses a threat of slowing down in saving and technology import—leading to ceasing development progression. Hence, the focus should be on the production and trading of technology ideas.

On the hand, per capital income out of technology consumption centric labor trading saturates very quickly. Similarly, natural resource based per capita income depends on the reserve and market value. At the best, both of them show linear model of income growth—proportionate to number of employable people and amount of salable natural resources.

But idea production and trading offers sustained growth path—endless opportunity.




In the 1960s, both Malaysia, Singapore and South Korea were producing economic value out of natural resource and labor.
But in the 1980s, Korea and Taiwan started adding value from knowledge and ideas.
Unlike Malaysia, both Taiwan and Korea have been enjoying sustained growth

# Dynamics in the Career of ECE Graduates: idea trade is gaining traction

ECE graduates can engage them in three different forms: i. in-house employee, ii. contractors, and iii. innovators.

The challenge for in-house engineers is to acquire ECE competence, and to qualify to get a job. Upon getting the job, in-house engineers keep working on technology based service delivery and also maintaining and developing customized solutions. Salary is assured.

Unlike in-house employees, engineers working as contractors do not have salary commitment from clients. They respond to request for proposal. They face challenges in winning bids and delivering solutions at profit to earn salary. In addition to knowing ECE, they need to be good in communication and project management. They also need to focus on remaining at the edge of state-of-the-art competence, showing creativity in proposal development, developing reusable assets, and optimizing cost of delivery. But the work order gives the assurance of getting paid.

However, despite high potential reward, there is no work orders or purchase commitment from potential customers. Innovators need to risk time and investment to envision customers' requirements, develop the product and make it available for the customers to decide. The perceived value and competition will determine the price that could charged and units could be sold. If that exercise generates profit, innovators get paid.

However, for reaching success of hitting profitable revenue generating ideas, we cannot rely on random experimentation of ideas—like the way Edison did. But Edison's decision of setting up corporate lab to scale up tinkering based idea of light bulb was remarkable.

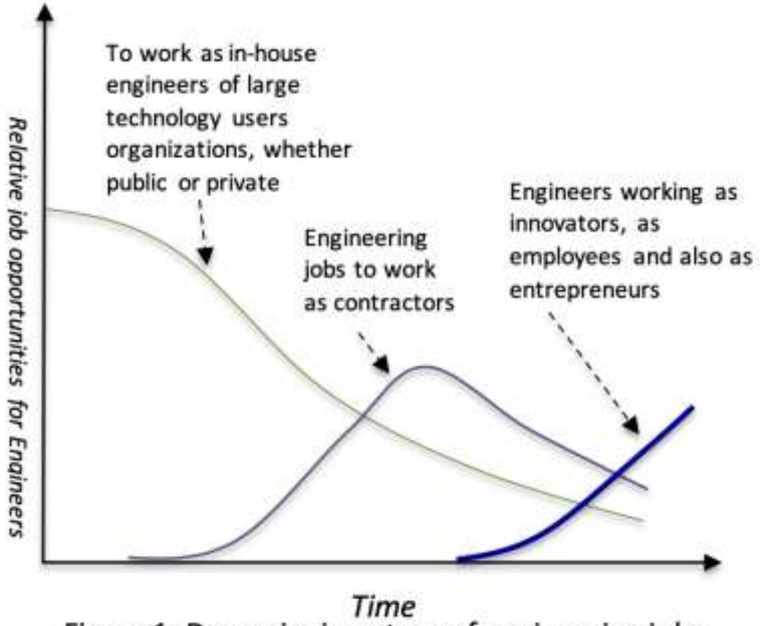



Figure 1: Dynamics in nature of engineering jobs

Due to the growing R&D investment need and negligible cost of integrating R&D outputs in each unit of innovation, the quality is growing, cost is falling and economy of scale is expanding.
This dynamic is making innovation is a better alternative to get ECE solution.

# Scalability of Grassroot Ideas: offers innovation opportunity to STEM graduates

Often, our thinking is dominated by global success stories and apparent insurmountable barrier. The supply of ideas and their utilization can take place in more than one stream. In addition to pursuing big ideas, we should also focus on the invention of millions of little ideas (for example, better ways to sew a shirt or grow, harvest, and package fruits), that make persistent economic growth possible.

People in farming or in aquaculture-among others-are after learning from experience for improving quality and reducing cost. Often, they organise whatever basic materials they get to implement their ideas. For example, ideas for using a small stick to give support to tree or plant branches could value. Of course, these ideas do not sound like great innovations.

But the economic effect of millions of producers and users of such ideas could be significant. If such grassroots ideas keep adding 2 per cent extra to the rural economy, the compounding effect of it over 10 or 20 years could be significant. Hence the focus should be on fostering creativity, idea production, integration, and diffusion at the grassroots level. Our primary level education should take special measures to build such innovation capacity among millions of students.

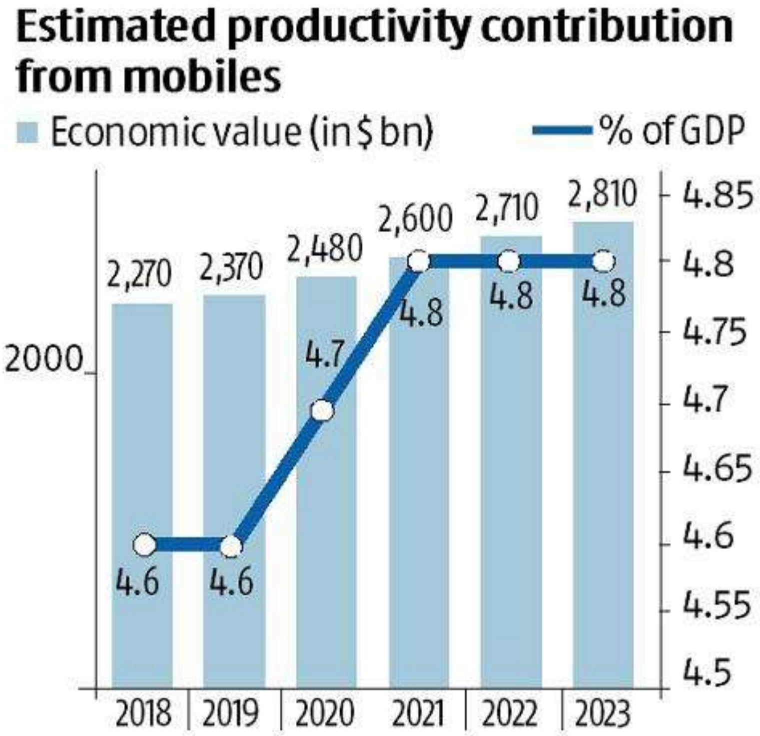
To begin with, a linkage should be established with science and engineering schools to transfer intuition and craftsmanship into science and engineering. The next step would be to have intellectual property ownership so that initial innovators get a fair share. The next step should proceed to institutional R&D for creating a flow of ideas for scaling up, through improving the quality and reducing the cost out of intellectual assets (as opposed to subsidies, tax differentials, or other incentives). This endeavour will lead to start-ups for large-scale commercialisation or diffusion.

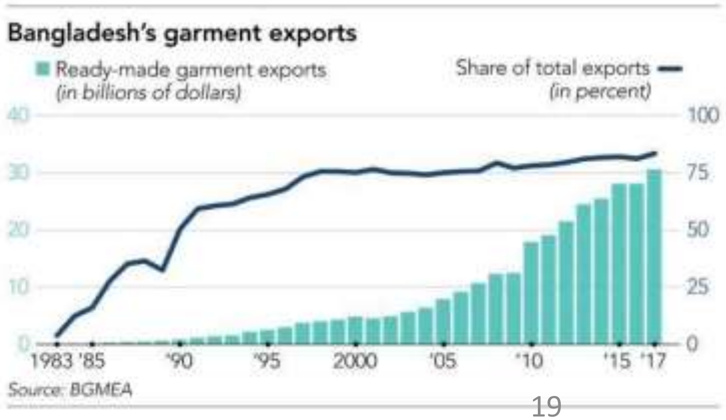
Despite low tech impressions, scaling up numerous grassroots innovations offers us the opportunity to engage graduates to pursue high-end science and engineering in producing ideas and integrating them into products and processes in creating profitable revenue.

Technology possibilities in scaling up vertical oyster farming—in deep water

# Creating and Capturing Economic Value out of Technology Possibilities:
## Smart Technology Users—extracting value out of usages

- Technology use creates economic value—could be measured as consumer surplus. Hence, savings from labor and natural resource trade could be used to import and use technology to create further economic economic value.
- For example, usage of telephone reduces the cost of communication. Hence, the investment made for telecommunication network development out of imported technology itself makes positive contribution on economic growth.
- Similarly, the adoption of imported technologies in the transportation sector for reducing accidents, reducing fuel consumption, lowering emission, and reducing travel time have the potential to have net positive effect.
- But such economic value creation is limited to the amount could be saved from labor and natural resource trade. Hence, it does not offer sustained growth path. The growth is limited by the economic value creation ability out of labor and natural resources.
- Furthermore, imported technology also expands the scope of economic value creation out of labor and also natural resources. Technology import has enables many less developed countries to turn their surplus labor into productive activities. For example, Bangladesh's RMG sector is the success story of creating employment of low skilled workforce out of technology import.



# Technology Service Providers:

- Economic value could also be derived by producing services out of technology. There are two major categories of services: i. technology development and innovation, and ii. Technology operation management services.
- For example, India has created a large economic sector through the export of technology services. They have been active in both of these categories. American and European companies engaged millions of programmers, remotely, to update their legacy software applications. Indian technology people have been also delivering IT operation management services.
- The growth of chip design services, including on ship software development, has been growing technology service sector.
- This approach of economic value creation out of technology service shows linear model of revenue. Total value could be created us determined by the number of people employed and per person charge out rate. Hence, per capita income saturates at the full employment.

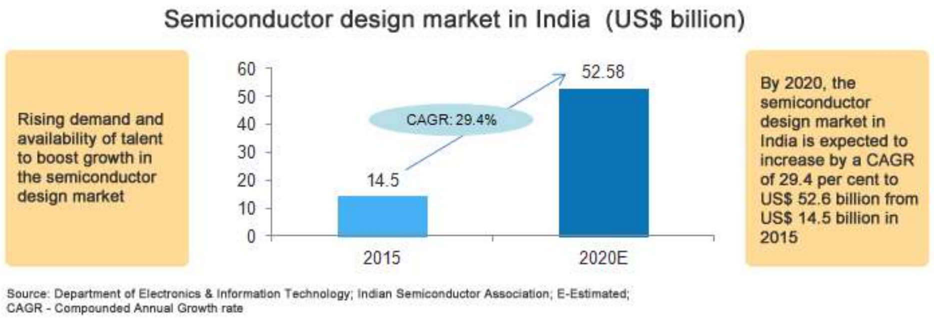
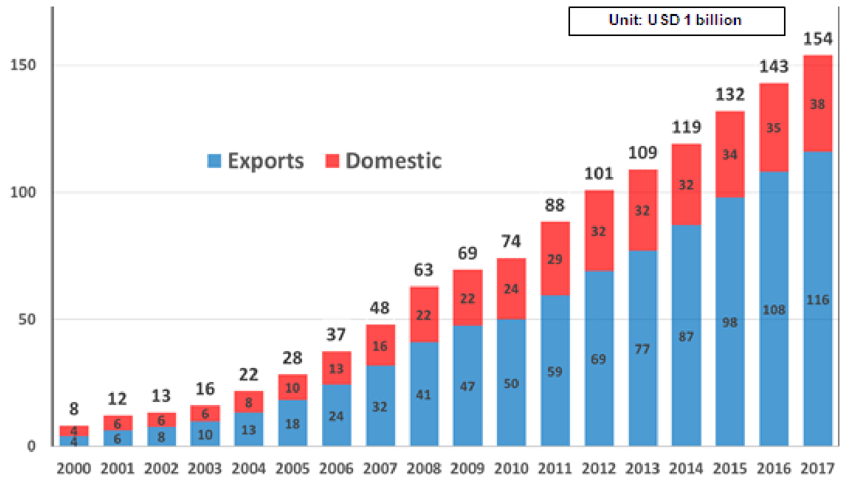
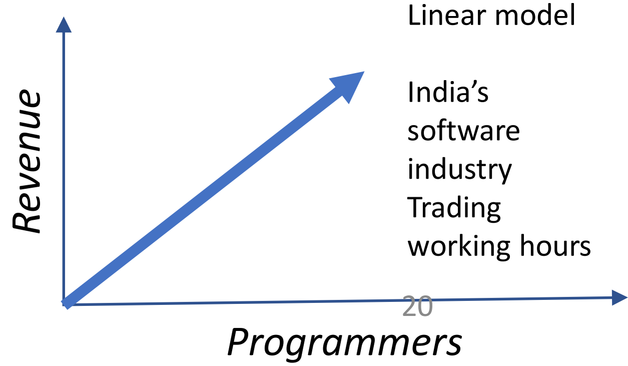



**Fig. 1: India's IT-related service revenues**




Note: Figures for the various years are from April the previous year to March that year.
Source: NASSCOM



# Technology Intensive Manufacturing:

Value from technology could also be derived from manufacturing services. Through manufacturing services, both labor, knowledge and ideas could be leveraged. For example, Semiconductor manufacturing service providers turn knowledge and ideas of highly-educated work force into growing yield of chip processing.

In addition to optimally running operation, they also focus on process innovation. Instead of taking advantage of low cost labor, they focus on the quality, cost, scope, and scale advantage of emerging production technologies.

One of the notable examples has been Taiwan Semiconductor Manufacturing Company. Humble beginning in the mid 1980s has reached global success story—being one of the two 5nm process technology based service providers.



TSMC's Revenues have grown steadily in the past 20 years, reaching a record high of NT $317.41 Billion in 2006.

| | |
|---|---|
| TSMC's Revenue | •NT$1.33 trillion (US$47.95 billion) (2020) |
| Operating income | •NT$372.7 billion (US$13.37 billion) (2019) |
| Net income | •NT$517.89 billion (US$18.53 billion) (2020 |

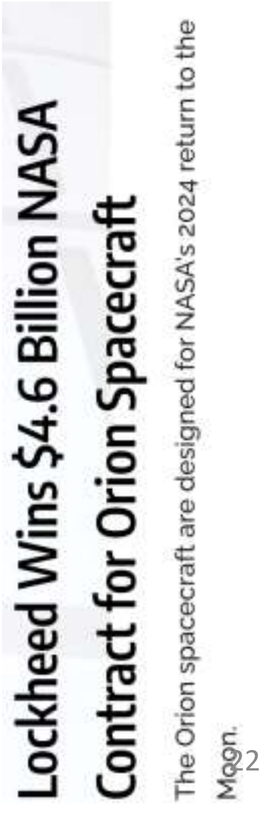
## In-house Custom Solution Providers and Contractors:

Technology value could be derived through customized application development too. As a matter of fact, most of the major technologies started the journey for serving the customized application development. For example, Fairchild sold the first batch of transistors to IBM for developed customized computer for US air force's B52.

Similarly, in the 1950s, US Air Force pursued customized application development for air defense. The Semi-Automatic Ground Environment (SAGE) system of large computers and associated networking equipment that coordinated data from many radar sites and processed to produce a single unified image of the airspace over a wide area was not only pushed the technology envelope, it was the breeding ground for USA's software technology capability.

Even today, customized application development, primarily for military and large public application, has been pushing technology envelope and producing substantial revenue. Some of the global firms are Lockheed and Raytheon. Even, IBM and Siemen has a large business of customized application development. Recently, Microsoft has got involved with US defence for offering customized applications around its hololens technology.

Members of the U.S. Army sporting Microsoft Hololens headsets. U.S. ARMY



Lockheed Wins $4.6 Billion NASA Contract for Orion Spacecraft

The Orion spacecraft are designed for NASA's 2024 return to the Moon.

Microsoft wins U.S. Army contract for augmented reality headsets, worth up to $21.9 billion over 10 years

# Idea Building Block or IP Provider:

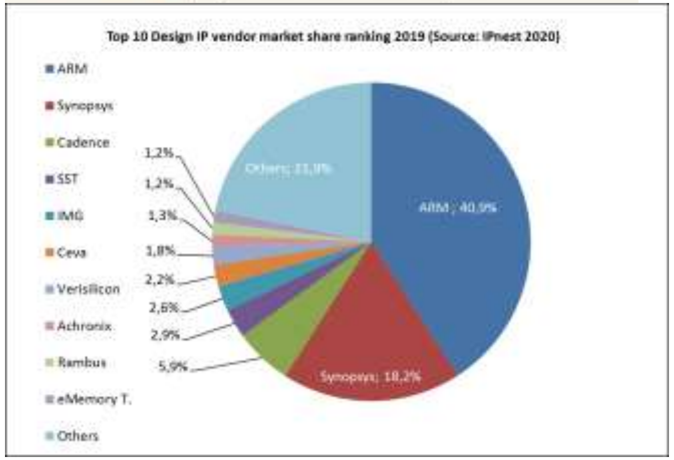
All major products, whether hardware or software, contains several IP building blocks. They could be developed and licensed.

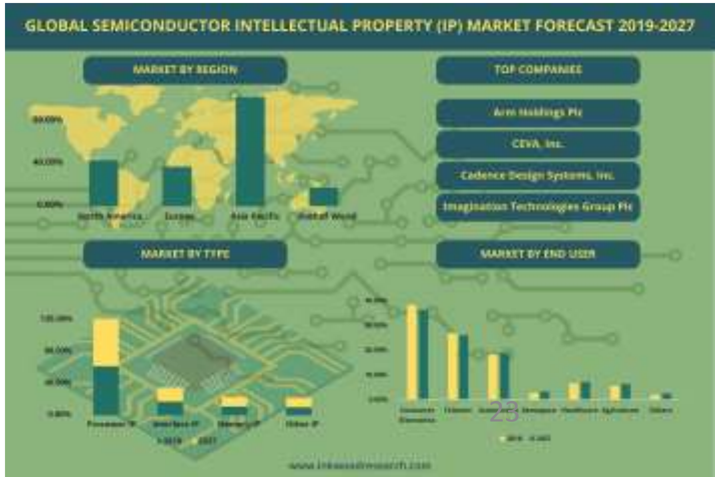
For example, the semiconductor industry has a rich history of IP development and trading. One of the notable example is ARM holdings.

ARM Holdings Plc designs microprocessors, physical intellectual property (IP) and related technology and software. In 2000, ARM's revenue from IP trading was more than $2 billion. In September 2020, Nvidia agreed to buy ARM for $40 billion.

Another one is cyber security segment. In 2016, Israeli firms export over $6 billion a year worth of cybersecurity services and products (mostly IP), according to the Cybersecurity Review. Israel's share in the market has soared from two to three percent five years ago to 10 percent of the total market worldwide.

In addition to R&D capacity development, focus should be on legal aspect of intellectual property protection, defending, and monetization. Due to growing economic prospects,  semiconductor patenting and related litigation activity are regularly in the spotlight today.  There should be focus to obtain adequate clarity on the role of the intellectual property (IP) system for tradable ideas.

# Component Innovator:

A opposed to innovating a finished product, whether for consumers or business customers, you may target to exploit technology possibilities out of your knowledge and ideas as component innovator.

For example, Sony has been developing image sensor intellectual assets, and rolling them out as components—image sensors. Those image sensors are being used by many product innovators, including Apple. Similarly, Intel created huge business out of developing and supplying components to Personal Computer Maker.

As opposed to labor, the focus should be on generating knowledge and ideas and integrate them into the design and production of components. This journey even may begin as customized component developer and supplier. For example, Intel was contracted by a Japanese calculator maker Busicom to develop a chip to power its calculator—leading to the design of 4004 chip. In fact, this is was the first microprocess. Subsequently, Intel updated it and roll out Intel 8080—starting a long journey of releasing subsequent better versions. In course of time, Intel started building a large business in innovating and supplying micro processors (like 8088, 80286,…, Pentium) to PC makers.

In fact, Apple sources components from more than 200 suppliers for its iPhone. Often, it's a less risky path to grow as component supplier. To succeed in this path, keep producing intellectual assets for rolling out successive better versions, preferably at falling prize.

On the left, the NEC TK-80 kit, based on Intel 8080 chip, on the centre, Busicom calculator motherboard, based on Intel 4004 chip, and on the right, the Busicom calculator, fully assembled in Ueno, Tokyo

# Process Equipment Innovator:


Technology possibilities could also be harnessed by developing intellectual assets and trading them as production process equipment. For example, Tokyo Electron, Applied Materials or Canon have developed a large business in conducting R&D in how to process silicon wafer with higher precision, and trading the R&D outputs as process equipment.

For creating an entry, they often begin the journey as contractor—for developing and supplying customized process equipment. Subsequently, they keep updating them as standalone building block to engineering a production plant.

For making entry, it demands to be vigilant to the early growth stage of an industry, and forming partnership as customized equipment provider. The challenge is to turn customized solution into standard building block, pluggable with other process equipment—often supplied by other equipment makers. The next step is to keep releasing successive better versions and innovating a set of complementary building blocks. It demands a very strong partnership with lead customers and also R&D capacity. For example, even after 55 years or formation, Tokyo Electron recently got involved in a R&D partnership with TSMC for developing process equipment for 2nm silicon chip production process. In fact, more or less, all the robotics companies are process equipment innovators and suppliers.

# End-user Product Innovators:

Often, finished products, whether for consumers or business customers, dominate the discussions of ideas, inventions and innovations. But, each of those remarkable product innovations also rely on component and process innovations. In certain cases, intellectual challenge of component or process innovation is far more challenging that innovating finished products. For example, for keep meeting the demand of every growing performance of battery to power high-end smartphones, continued R&D in lithium-ion battery led to winning Nobel Prize.

But at the end of the day, finished product innovations create the demand for component and production process equipment. Hence, it's a very important area to focus on to exploit technology possibilities.

In addition to technology capability, finished product innovation demands a very high focus on understanding end user preferences. In some cases, aesthetic appeal is far more important than technology and functional capability of products. For example, Nokia became a major mobile handset maker by tapping into the aesthetic part making mobile handset as a fashion item.

To succeed as finished product innovator, there should also focus on forming partnerships with component and process equipment provider. For example, Apple as a strong partnership with Foxcon in developing next generation robotics to support the production process of Apple products like iPhone.

# Startups—for pursuing creative destruction

This is about nurturing high-value ideas to offer better substitution to existing products—causing destruction to the demand of existing products and capacities to produce and distribute them.

History of the startup journey could be divided into four distinct phases:

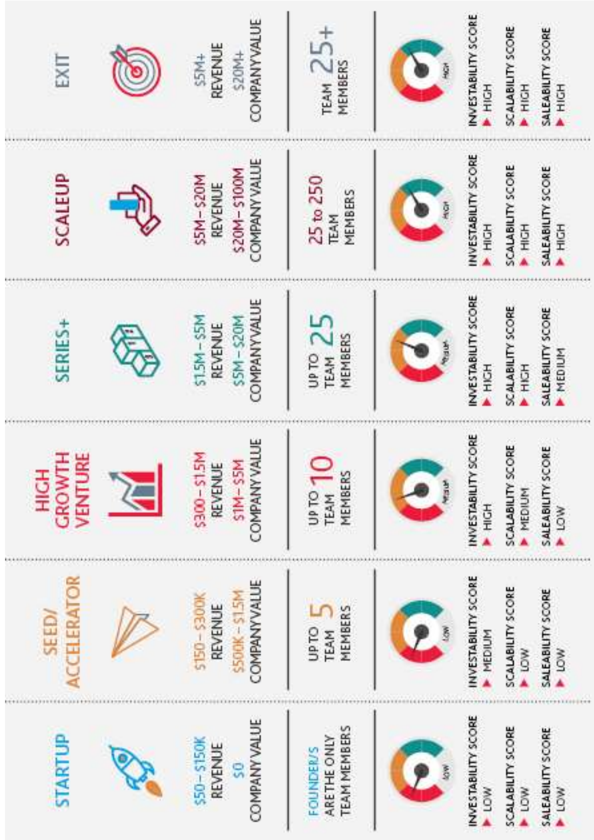
**Phase 1:** During the 19th century, out of tinkering, Edison and many others came up with ideas, got patents, and started rolling out innovation—even through craftsmanship.

**Phase 2:** In the USA, just right after WWII, institutional R&D for war agenda led to the formation of some technologies for rolling out innovations for defense and civilian applications. Consequentially, it led to new companies (spinoffs, startups) by R&D staff members, graduate students, and professors.

**Phase 3:** The growth of silicon technology led to the ideas and formation of startups around personal computers, handheld devices, and software applications. The scalability of silicon and software was the underlying force in turning some of these startups into highly valuable corporations like Microsoft, Apple, and many more. But it was not naturally occurring.

**Phase 4:** Digitization ideas around the smartphone, mobile Internet, and cloud computing led to the formation of the latest startup rush. This time it has propagated to the developing part of the world.

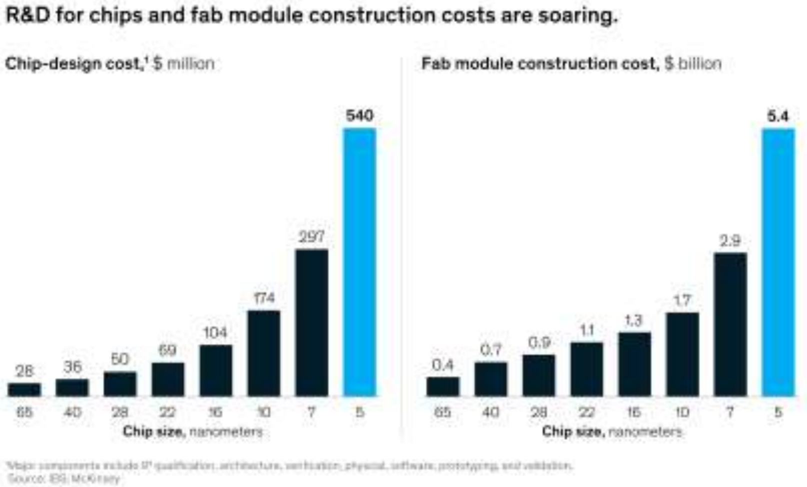
Great ideas must be complemented with a flow of ideas. And they do not keep coming out of informal work setting, brainstorming, or idea competition. It demands systematic research. Instead of it, subsidies in increasing customers for inflating valuation run the risk of burning investors' money, failing to create wealth, and indulging in fraudulent practices.

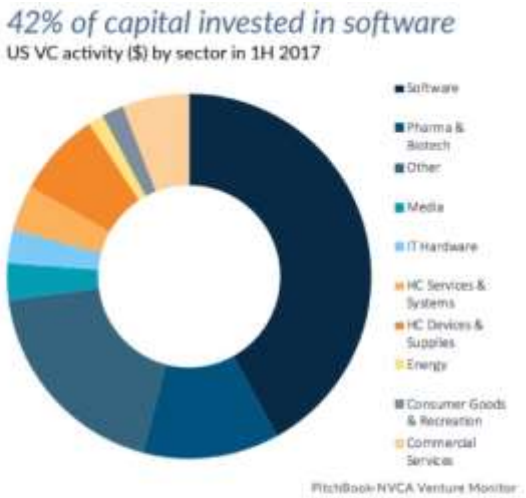


# Growing Challenges to Exploit Ideas

## Growing Investment Need for Idea Production and Exploitation:

- As shown, upfront investment need for idea production has been exponentially growing—notably, in semiconductor.
- Low hanging fruits out of the silicon and software technology potentials have been already picked up.
- The challenge of creating willingness to pay out of technology ideas has been increasing, as the gap between value propositions between incumbents and emerging ones has been growing.
- Furthermore, attempts to imitating humans' innate abilities with machine capability has been found to be far more, or unknown, than the hurdle that was required to overcome to imitate codified knowledge and skills.
- For example, upon spending more than $80 billion in R&D, autonomous vehicle idea is far from needed maturity to roll out on the street as better alternative to  human driver. Perhaps, in history, this idea exploitation mission has already consumed far more resources than any other idea has ever been pursued by human race.




Why are software ideas taking so much venture capital finance?

## Increasing Decision Making Challenge to Profit from Ideas:

- Yes, there have been growing possibilities—but they have been demanding growing investment, and also posing increasing uncertainty.
- The challenge is to look for discontinuity, find ways to keep building capacity, and keep trading and generating revenue.
- The decision making challenge is to create snowball effect out of humble beginning.
- For example, Tesla went after exploiting the economic value out of lithium-ion battery through electric vehicle. This decision has been demanding huge risk capital and Government's supports to reach profitable revenue.
- On the other hand, Japanese companies got into it exploiting profitable revenue from the very beginning. As opposed to targeting big bang, it focused on gradual progression and progressive exploitation. For example, as opposed to making electric vehicle, they started exploiting its potential from innovating digital camera, and supplying battery to other device innovators like mobile handset makers.
- Similarly, TSMC started the semiconductor processing service in a very humble manner—requiring very little investment and facing minor decision making risk. But through a series of rational decisions it has been building a momentum out of profitable revenue generation—as opposed to incurring loss for decades.
- Similarly, Toyota has been developing battery technology and progressively exploiting its potential from hybrid to plug-in electric vehicle. In fact, progressive exploitation of potential is an important element of decision making in the midst of uncertainty to leverage technology.

# High-Tech Journey of Bangladesh and Taiwan—was there a common root, but got split into different paths?

In the 1960s, Bangladesh and Taiwan had the same type agrarian economy. However, Taiwan's TSMC has taken over the silicon edge from Silicon Valley, and Bangladesh yet to show miracle.

Ironically, these two countries had a commonality in its high-tech endeavour. In the 1980s, both of these countries listened to their respected non-resident experts and provided finance to start rolling out their high-tech ideas. Taiwan appointed Dr. Morris Chang as the Chairman of ITRI, and Bangladesh appointed Dr. Rafiquzzaman as the computer advisor to the President. Interestingly, both of them had PhDs in Electrical Engineering and they had a long professional career in the USA. Subsequently, both of them got financial assistance from their respective Governments to roll out commercial ventures.

Dr. Chang started TSMC, for leveraging a discontinuity in a very humble manner, for offering silicon wafer processing services. That humble beginning has grown into a mega success story. Even, it has taken away the silicon edge from the Silicon Valley, and made US senate nervous to roll out $52 billion rescue package for the USA's semiconductor industry.

As opposed to processing silicon, Dr. Rafiquzzaman rolled out Rafi Systems for developing software and producing lens. His software arm ended up in disappearance, while India saw remarkable rise.

But what about the lens making endeavour? Coincidently, during the same time, a Taiwanese lens maker Largan got birth. Interestingly, it started with far less money than the money Rafi System got from Bangladesh's Bank. As opposed to Rafi system's focus on low-cost labor, Largan focused on developing knowledge and intellectual assets for creating an edge in lens making—leading to the rise of another shining star from Taiwan.

What is the lesson here? As opposed to creating success stories out of seed capital and blessing from the top, Rafi systems ended up in closure and failure to paying bank loan (as reported by the media a few years ago). Does it mean that, like Dr. Rafiquzzaman, many of us do not have adequate understanding about high-tech business dynamics in detecting discontinuity, required level of ethics in using public money, and ability to take decisions to keep nurturing humble beginning into mega success stories? Until we address them, will any amount of public money & supports, production of graduates, and infrastructure building create miracle?