

## CHAPTER 3 AN ENQUIRY INTO THE ECONOMIC GROWTH AND DEVELOPMENT: THE INNOVATION PERSPECTIVE

### 3.1 The Growth Theories

Until the 1970s the growth strategies of developed countries focused on *accelerating the rate of capital accumulation and technological adoption. Import substitution, state owned enterprises, control over the financial sector, central planning.* However the second half of the 1980s saw a shift in the views and new growth theory emerged in the 1990s. Upto then the Solow model dominated in which growth is a function of accumulation of capital, accumulation of labour and the productivity growth. This model views long run growth as entirely determined by exogenous factors, independent from structural characteristics of the economy such as openness, scale, saving rate and the most important the policies influencing such variables. Solow however himself estimated that technological change explained more than half of per capita output growth in the first half of the 1990s in the USA.

Romer and many others succeeded in creating models in which technological progress was endogenous to growth. In his magnum opus "The theory of Economic Development", Schumpeter had also mentioned the view related to economic development in which "changes in economic life are not forced upon it from without but arise by its own initiative from within." Advances in the modeling of non competitive equilibria (Romer 1983, 1986) allowed the development of a new set of endogenous growth models in which national policies could influence not just the level of income but also the countries' steady state growth rates (Grossman and Helpman 1992; Aghion and Howitt 1998)

In the working paper "Endogenous Innovation in the theory of Growth" Gene M. Grossman & Elhanan Helpman examine whether the neo classical model-with decreasing returns to capital, and exogenous technology-fully explain the cross country variation in per capita incomes and national growth rates. Paul Romer (1986, 1989a) was not in agreement due to the following reasons:

- 1) The growth rate of the world's technological leader should not have been rising as it did because this could happen in neo classical model only with the steady acceleration of the pace of exogenous technological progress; and,

2) Countries did not appear to be converging to a common level of per capita income, as neoclassical model suggests, if they share similar savings behaviour and technologies.

Gene M. Grossman & Elhanan Helpman questioned the standard procedure of changes in output into parts associated with the growth of various inputs, and a residual. The residual, which depending on the particular study may be large or small, is often taken to measure the contribution of advancing technology to growth. He observed

*“Unfortunately, there are problems with this interpretation. For suppose that  $Y = AK^{\alpha}L^{1-\alpha}$ , where  $Y$  is output,  $K$  is capital,  $L$  is labor and  $A$  represents the state of technology. As a matter of arithmetic, it is of course true that the percentage growth in  $Y$  will be equal to the sum of the percentage growth in  $A$ ,  $\alpha$  times the percentage growth in  $K$ , and  $(1-\alpha)$  times the percentage growth in  $L$ . But can we conclude from this that the growth in  $A$  measures the full contribution of technological change to the expansion in output? Evidently not. After all, technological improvements typically raise the productivity of capital and thereby induce additional investments. In such cases, the resulting capital formation ought not to be considered as an independent spur to output, but rather as a facilitator of the growth that is due ultimately to the innovation.”*

In another study, Prof. Abramowitz measured the growth in the output & the growth in inputs of labour and capital of the American economy between 1870 and 1950. The findings were surprising as the measured growth of inputs (i.e., in capital and labor) between 1870 and 1950 could only account for about 15% of the actual growth in the output of the economy. There was an unexplained residual of no less than 85%. Various other economists in the late 1950s and 1960s attempted similar exercises with different time lines and methodologies, different sectors, but they also found the residual to be very large. Solow himself discovered a very large residual – 85%. It was precisely the size of this residual that persuaded most economists that technological innovation must have been a major force in the growth of output in highly industrialised economies. (Rosenberg).

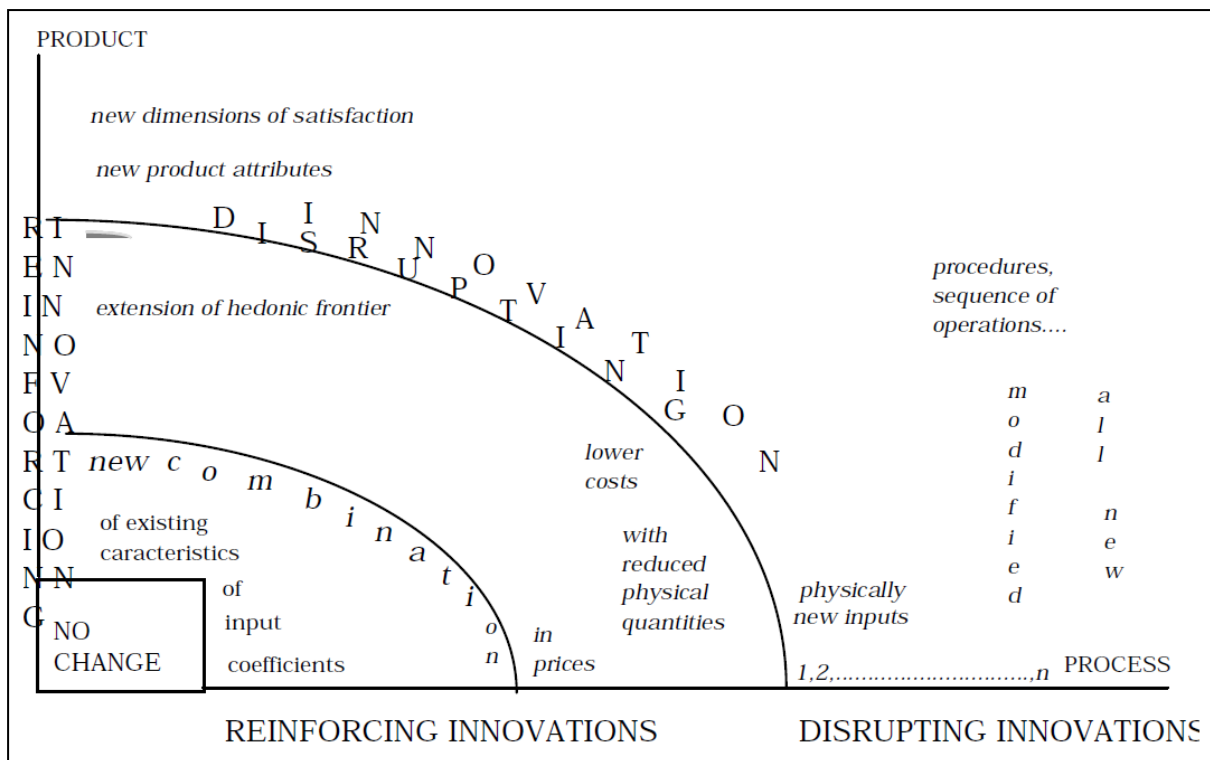
That Innovation leads to growth and economic development has also been illustrated by the well known economic historians like Landes (1969) who described the role of new technologies in industrial revolution. Rosenberg (1972) provided a comprehensive survey of

the relationship between technological advances and the economic growth of USA. Fogel (1964) admitted that the single innovation of the railroad added 5% to US GNP by 1890.

### 3.2 The impact of Innovation on the Economy & the Impact of economy on the innovation

*In economics, the concept of innovation has been derived from the theory of production (Frisch, 1930), i.e, as a change in production function or technique.*

**Figure 3.1: Innovations**



Source: DeBresson

**Luecke and Katz (2003) defined innovation as** the successful introduction of a new thing or method .Innovation is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services. **“Luecke and Katz (2003)**

Joseph Schumpeter defined economic innovation in *The Theory of Economic Development*, (1934) . Well did he observe:

*“The first thing to go is the traditional conception of the modus operandi of competition. Economists are at long last emerging from the state in which price competition was all they saw. As soon as quality competition and sales effort are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular ... that practically monopolizes attention. But in capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives” Schumpeter, 1939*

Thus Schumpeter defined Innovation as

- *The introduction of a new good*
- *The introduction of a new method of production,*
- *The opening of a new market,*
- *The conquest of a new source of supply of raw materials or half-manufactured goods,*
- *The carrying out of the new organization of any industry*

The economists worldwide have studied Innovation from different perspectives.

**Table 3.1: Innovation studies**

S.No.	Study of Innovation	Economists
1	The new sequence of operations	Ragnar Frisch (1930,1965);Nicolas Georgescu-Roegan (1971); Leontief (1989); Egidi (1986) ; Foray(1987)
2	Techno-economic & hedonic advance	Lancaster;Trajtenberg(1990)
3	Measuring the new factor proportions	Frisch (1930);Leontief
4	Innovation induced investments & business cycles	Schumpeter, 1912; Kuznets, 1930; Rostow, 1960; Clark 1961;
5	The location of innovative actors & interactions in the economy	Schmookler,1966.Walsh et al,1979) Schere (1982c) Aitken (1985), Bengt -Ake Lundvall (1988,1992)
6	The Entrepreneurial functions	Cantillon(Universal and common entrepreneur), Chamberlin, Lancaster,Hicks

		Substitutor Hicks factor induced innovator, Schmooklers' demand induced innovator, Menzer, Kirzner, Brenner, Schumpeter (Heroic)
7	Organisational interactions & Innovation	Von Hippel, 1989, Lundvall, 1985: the importance of supplier-user relationship. Innovative achievements are the result of "multiple cooperating visible hands"; DeBresson and Amesse, 1991; Teubal et al: Creation of market for the new technology
8	Inter industrial analysis	Myers & Marquis, 1969; Utterback, 1975; Rothwell et al, 1974; Teubel, 1987; Von Hippel 1976, 1989; Lundvall, 1988 emphasised the first users role in the process of innovative creation
9	Division of labor, Structural change & economic growth	Stigler (1951). Rosenberg (1965), Richardson (1975) Leontief (1936) and Sraffa (1951) Grossman & Helpman (1989), Romer (1990), Aghion and Howitt (1992) Becker and Murphy (1992)
10	The Keynesian Theory & structural Change	Freeman, Clark and Soete 1982) Freeman (1984) Rosenberg (1976, 82) Schmookler (1966) Luigi Passinetti (1981) Garegnani (1992) Nell (1994)
11	National System of Innovation	Freeman 1987; Anderson & Lundvall, 1988; Lundvall, 1988, 1992; Nelson, 1988, 1993
12	Micro Economic theory of technical advancement	Scherer (1967b) & Barzel (1968), Kamien & Schwarz 1972a, 1974a, 1974b, 1976b, 1978a, 1978b, 1980b) Loury (1979), Scherer (1967b) Olivera (1973), Lee & Wilde (1980) Dasgupta & Stiglitz (1980b), Reinganum

### 3.2.1 The impact of Innovation on the Economy

There have been studies that aim to quantify the growth impact of specific innovations through the growth accounting framework. The innovations contribution to growth is assessed through (i) capital deepening measured by the growth of capital inputs associated

with a particular innovation and (ii) TFP growth in the sector that produces the goods underlying the innovation. (Oliner & Sichel,2003;Crafts 2004)

Crafts (2004) studied the impact of steam technology on British economic growth during the late 18th and 19th century, and Oliner and Sichel (2003) examined the impact of ICTs on US growth in the last quarter of the 20th century.

**Table 3.2 Growth contributions from steam technology and ICTs in Britain**

	Steam technology in Britain				ICTs in the US			
	1700-1800	1800-30	1830-50	1850-70	1879-1910	1974-1990	1991-95	1996-2001
Capital deepening	0.004	0.02	0.02	0.06	0.09	0.41	0.46	1.02
TFP	0.005	0.001	0.02	0.06	0.05	0.27	0.41	0.77
Total contribution	0.01	0.02	0.04	0.12	0.14	0.68	0.87	1.79

**Source: Oliner and Sichel (2003) and Crafts (2004)**

The estimates expressed in terms of annual percentage contributions to labour productivity growth illustrate the delayed and long lasting impact of steam engine. The estimates for ICT suggest a higher overall contribution to growth than from steam technology, especially in the second half of the 1990s. The growth impact of ICTs also took time to materialize, though the delay is much shorter in comparison.

The above estimates are bound to underestimate the true growth impetus from the new technologies. Above all, the estimation approach only captures TFP growth in the technology-producing sectors. It ignores possible productivity spillovers in other sectors of the economy. In the case of steam technology, Crafts believes such spillovers may have been significant after 1850. At the same time, cyclical effects may bias the estimates presented in table-1 and may, in particular, cause an overestimate of the ICT contribution in the second half of the 1990s (Gordon, 2000).

Unfortunately, it is difficult to understand the precise impact of innovation on growth performance and different innovations, as the simultaneous impact of various technologies make it difficult to isolate the contribution of a single innovation. Also the adoption of

technology takes time. There exists certain issues like these, However Innovation drives economic growth & development cannot be denied.

A report published in 2015 by WIPO” *Breakthrough Innovation and Economic Growth*” explores how radical breakthrough innovations have made their impact on global economy citing the case study of six breakthrough innovations as follows:

- Airplanes – from hobbyists gliding in the 19th century to a reliable mode of transportation in the first half of the 20th century
- 3D printing – the creation of 3D objects through successive layering of material, aided by digital technology
- Antibiotics – from the discovery of Sulfa drugs in the 1930s to the birth of the modern pharmaceutical industry
- Nanotechnology –technology at the scale of one-billionth of a meter, with applications in electronics, health, materials, and other fields
- Semiconductors – from amplifying radio waves for better communication in the early 20th century to ever more potent computer chips driving the ICT revolution
- Robotics – from the first robots spurring industrial automation to today’s autonomous machines with artificial intelligence

The report illustrates the following impact of Innovation leading to the long run economic growth.

- **Capital Deepening**-The introduction of new technologies can encourage the firms to undertake new investments as they see better returns. Firms throughout USA increased their relative ICT capital stock as they saw the ICT boom.
- **Growth in labour force and human capital:** Introduction of new technologies, business processes and other Knowledge based activities demand better educated, healthier and skilled labour force.
- **Firm productivity growth:** Microeconomics of creation and destruction is quite visible in knowledge based economies. Innovation can cause entry and exit of the firms changing the industrial landscape. The introduction of Nano car by Tata set up the supply chain for the other automotive companies. Subsequently India witnessed

low-priced cars in the market by other companies. Meanwhile Reva-an electric car manufacturing company merged with Mahindra Electric and launch of E-20 became one of the pioneers in electric cars. Thus innovation brings growth enhancing efficiency gains and redeployment of production factors, the spillover effect of which can impact the dynamics of the economy.

- **Transformation of economic structures:** technological progress has prompted a substantial shift away from agriculture and industry toward the service sector. The GDP contribution of IT & ITES combined may be higher in India as compared to the contribution that of agriculture.

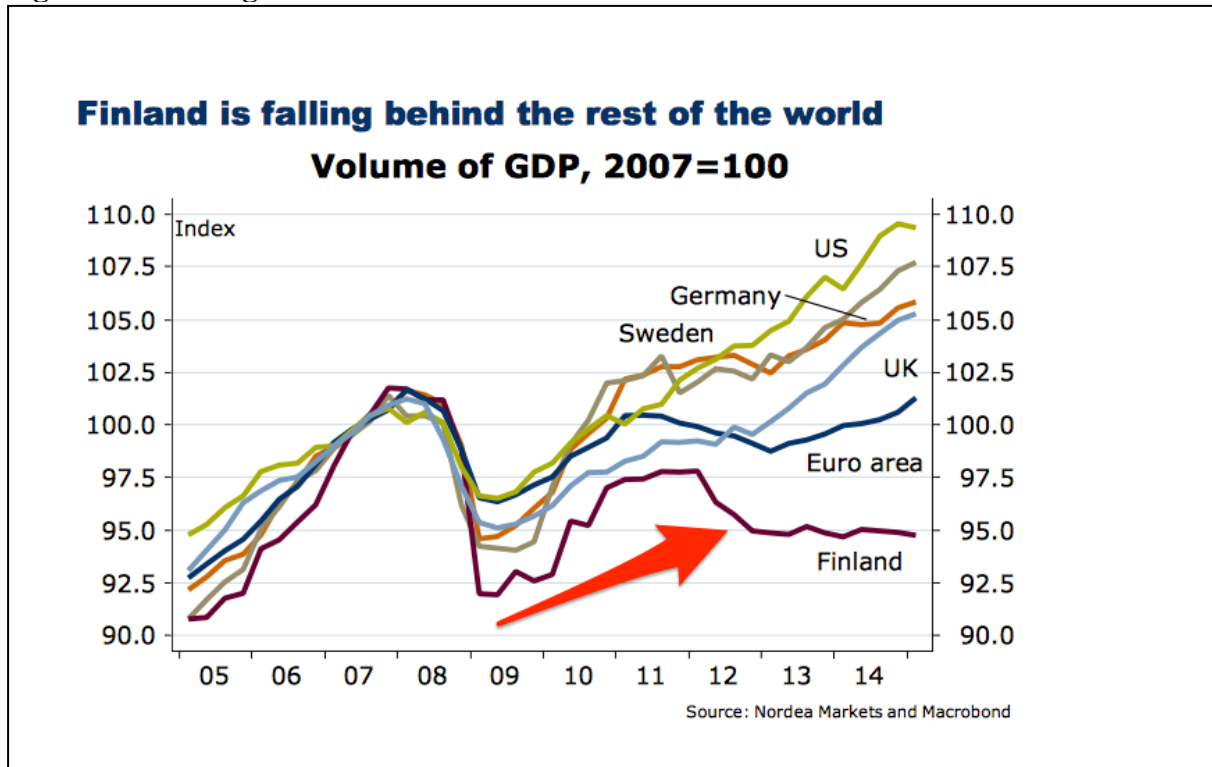
**Table 3.3: Company revenue as Percentage of GDP**

<b>Largest companies* in each domicile (Revenue as percentage of GDP)</b>		
<b>Company</b>	<b>Domicile</b>	<b>Revenue as percentage of GDP,2011</b>
ArcelorMittal	Luxembourg	161
Essar Energy	Mauritius	132
Royal Dutch Shell	Netherlands	56
China Mobile	Hongkong	34
Glencore	Switzerland	29
Statoil	Norway	24
PTT	Thailand	23
Hon Hai	Taiwan	20
Nokia	Finland	20
MOL Group	Hungary	19
<b>Source: Bloomberg; IMF; The Economist</b>		<i>*listed firms in 53 countries</i>

But Nokia that supplied 40% of the world’s mobile phones at its peak in the early 2000s crumbled following the launch of Apple iPhone and Android devices impacting the Finnish Economy significantly and contributed for less than 0.5%of the country’s output. With the seventh highest labour costs in the euro zone and labour productivity (GDP per hour worked) below the euro zone average, the aftermath of Nokia’s fall has undoubtedly increased the Finnish problems.

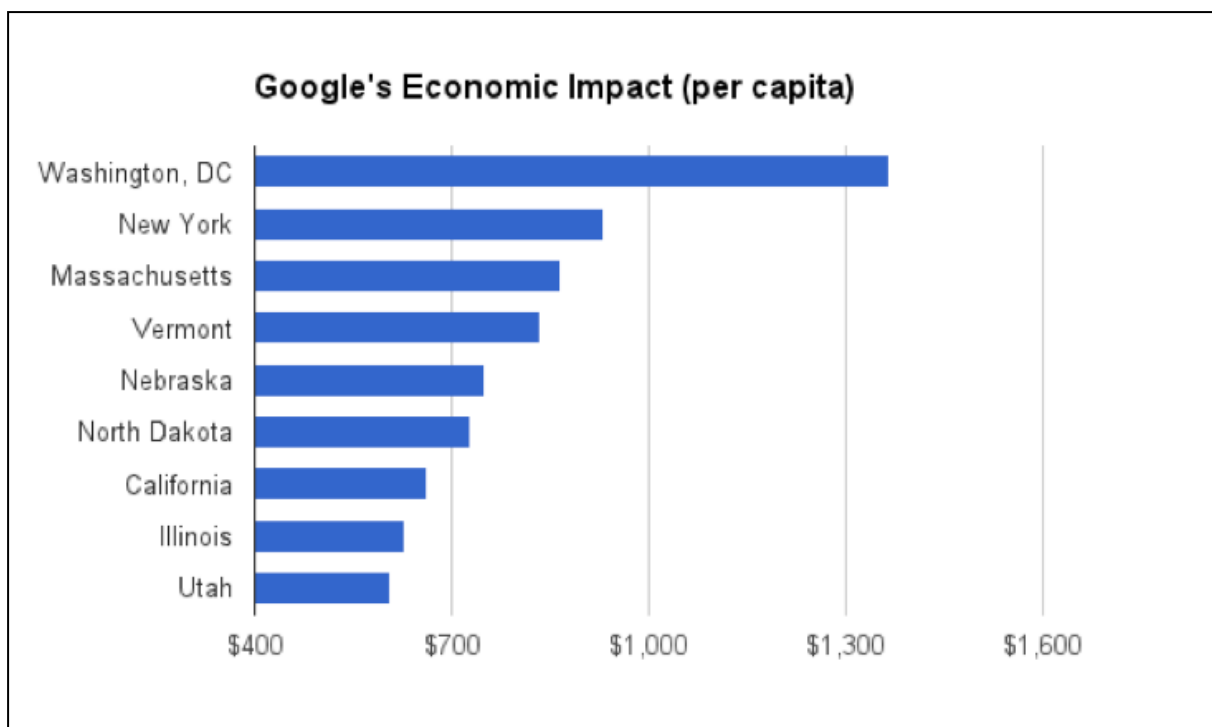


**Figure 3.2: Falling GDP of Finland**



Another good example is Google. The economic impact report by Google claims to generate \$111 billion in economic activity through more than 1.5 million businesses and non-profits nationwide. Another study showcases Google's per capita impact in different states of US.

**Figure 3.3: Google's per capita impact**



The Microsoft Economic Impact study by By Theo S. Eicher produces that excluding stock compensation and capital expenditures, Microsoft accounted for an estimated \$43.84 billion of Washington Gross State Product. The company generated a total of \$18.95 billion in personal income in Washington State, which was 6.8 percent of the state's personal income in 2008. The total economic impact of Microsoft amounted to 267,611 jobs or 8.4 percent of total Washington state employment in 2008. From 1990 to 2008, Washington employment grew at an average annual rate of 1.7% percent, while Microsoft employment expanded at a rate of 13.5 percent. Microsoft's employment multiplier was 6.81 in 2008, implying that every job at Microsoft supported 5.81 jobs elsewhere in the Washington state economy.

### **3.2.2 The impact of Economy on Innovation**

Why has the growth performance of economies varied so much over time and across the world? What fuels the innovation in an economic space? Why do innovative performance of economies differ? Few questions in economics have generated so much research. This section reviews the ecosystem which generates or drives innovation.

The Innovative performance varies from country to country. Why are some countries more innovative than others? In a seminal study, David Landes (1969) argued that Germany was so successful in the second industrial revolution because of the characteristics of its education and research systems, which were lacking in Britain and elsewhere. This helped Germany to create new industries based on chemistry and physics.

How does the economic environment affect the direction of innovation? The economic policies, systems & capacities play important role. Research efforts evidence various factors such as follows:

- The dynamics of learning & Innovation: In a rapidly changing world the existing knowledge and information of individuals, firms and other organisations become quickly obsolete. The pace of knowledge creation and knowledge destruction has accelerated. This context of rapid transformations, accelerating innovations and intense competition has been defined as a "learning economy" (Lundvall and Johnson, 1994; Johnson and Lundvall, 2000; OECD, 2000; Lundvall, Johnson, Andersen and Dalum, 2002). Economic structure and institutional set-up have an important influence in determining the rate and direction of innovative activities.

- **The Demand conditions:** Studies suggest that demand conditions in an economy influence the innovations. Demand should influence product innovation more than process innovation (Lunn 1986). Heterogeneous demand directed toward series should enhance product innovations (Pavitt 1984). High price elasticity of demand should stimulate process innovations. Low price elasticity should stimulate product innovations (Spence 1975). Innovation elasticity of demand should stimulate product innovations, thus resulting in an increasing concentration level (Gomulka 1990). In an initial phase, product innovation should be the main type of innovation, followed by product/process innovation and then by process innovation (Utterback and Abernathy 1975). This is due to diminishing uncertainty.
  
- **Market structure:** The market structure of an economy also plays its role in determining the types of innovation. Concentration should be a characteristic of process innovation (Scherer 1983) but not for product innovation (Lunn 1986). If the high quality firm is a Cournot (quantity) competitor it opts for product innovation, but if it is a Bertrand (price) competitor it opts for process innovation. The low quality firm acts in the opposite manner (Bonanno and Haworth 1998, quoted in Le Bas and Cabagnols 1999).

Some of the other important factors include:

- Universities and their relations with the economy;
- The growth of technology policies & the innovative capabilities;
- The changing rationale of government laboratories;
- The growing role of regions in fostering innovation;
- The capability of the government to adapt to rapid changes in innovation systems;

What kind of ecosystem best supports the flourishing of innovation and the adoption of new technologies? The report “break through innovations and economic growth” by WIPO point to a number of well-known elements of success:

**1. The role of the Government as the main source of funding** for scientific Research. In many cases, governments have played a crucial role in initially moving promising technology

from the laboratory to the production stage – often motivated by national defence and industrial policy interests. The role of the Government also includes financing R& D and in some cases playing the role of the lead user.

**2. Competitive market forces and efforts on the part of firms** were equally crucial, especially in commercializing promising ideas and engaging in follow on innovation that facilitated scaled-up production, cost reductions and wide-scale adoption of new technologies.

**3. Linkages between the various innovation actors** mattered. Linkages range from informal knowledge exchanges, professional networks and worker movements to formal university–industry licensing frameworks and R&D collaborations. The sharing of knowledge among researchers and connections with the upstream and downstream activities that help transform promising ideas into commercial technologies. The development of aviation – from the Wright brothers’ breakthrough achievement of powered, controlled and unassisted flying for 56 seconds in 1903 to reliable long-distance air transportation in the 1970s – is the result of many incremental innovations and improvements from different technological fields. These innovations were the result of interactions between many elements of the airplane innovation ecosystem, which includes the role of the inventor, academic institutions and governments and the economic environment in which innovation occurred.

**3. The absorptive capacity of the Economy** that entails the ability to undertake incremental or radical technological and organizational innovation in order to adapt technology to local needs.

**4. The strong IP protection regulatory framework** that incentivises innovation.

**5. The knowledge sharing arrangements:** In the case of semiconductors, cross-licensing agreements have been found to be important for the commercialization of new technologies and follow-on innovation. Today, many firms engaging in 3D printing, nanotechnology and robotics research have embraced open innovation approaches. They recognize that they may be better innovators by collaborating with others even if that involves some sharing of proprietary knowledge.