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Historical Perspective of the Role of Technology in Economic Development

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Abstract

The focus of this paper is to investigate technology changes and influence on economies since the First Industrial Revolution. The First Industrial Revolution was the first point in time when both increase of GDP per capita and population occurred at the same time (avoiding the Malthusian trap). Thus the selected point in time. Furthermore, developments of the late 18^{th} and 19^{th} centuries have some common properties with development of new technologies today. Even though the process of technological change changed during this time, there are still some lessons to be learned from distant and near history on how to gauge policies for fostering successful technological advances.

Changes that occurred are relevant for respective economies, industries, companies and individuals. On all these levels changes occurred that were unprecedented in history before the First Industrial Revolution. It is not suggested that technological progress of centuries before the First Industrial Revolution was insignificant, but it certainly did not have such a profound impact in all areas of human life and existence.

Keywords
development, economic history, technology

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Introduction

The technology, technology change and technological progress have played and important role in development of human kind. In this research we will not discuss overall history of technological progress, but rather, we will take a stand from an important historical event that happened in 18th century in Britain.

This event was the First Industrial Revolution, so we build our story from this point in time onward. By doing this we will evaluate the historical perspective from two accounts. One account will take into consideration developments in terms of industrial revolutions. The second account involves historical perspective of catch-up process among countries related to technological changes in production process, in innovation and invention process, and developments that influenced further increases of expenditures for science and technology.

Industrial Revolutions

The first instance in history where a society broke through from agrarian society to industrial domination is associated with the First Industrial Revolution. Landes (2003) distinguished two separate meanings and use of the word “industrial revolution”. The first one is the “industrial revolution” in small letters, which refers to the “complex of technological innovations which, by substituting machines for human skill and inanimate power for human and animal force, brings about a shift from handicraft to manufacture and, so doing, gives birth to a modern economy” (Landes, 2003: 1). The second instance is when the words are in capital letters, where they encompass a different meaning denoting “the first historical instance of the breakthrough from an agrarian, handicraft economy to one dominated by industry and machine manufacture” (Landes, 2003: 1).

How big was the difference between the life before the First Industrial Revolution, sometimes compared to the change after discovery of fire, is coined in Landes’ words (2003: 5): “…the Englishmen of 1750 was closer in material things to Caesar’s legionnaires than to his own great-grand-children.”

This is not to say that there were no important technological advances in history before the First Industrial Revolution. On the contrary, China in the 14th century was probably far more advanced than Europe. However, all the advances before the First Industrial Revolution did not yield the process in which countries became industrialized.

The First Industrial Revolution is a product of the eighteenth century. It encompasses variety of innovations, especially in the cotton industry of England. It was the time of transformation from handicrafts to factory system of production. The very important effect of the Industrial Revolution was that it was self-sustainable, unlike the situation before the Revolution, where any improvement in conditions and opportunities were dampened by the increase in population, thus keeping income in the low level equilibrium trap (Malthusian trap). This situation can be, in some sense, related to the developing countries with high population growth today.

There are two important senses that deserve the label “revolution”. First, technological advance made possible to escape from the Malthusian trap where rising population matched or even outstripped growth in output, thus preventing any rise in GDP per capita. At this point Britain was able to accommodate population growth of up to 1.5 percent annually, unlike before 1700, where population growth above 0.5 caused real wages to fall. At the same time Britain became the richest European economy. Second, Britain went through a period of rapid structural change in employment. The change was towards much urbanised and industrialised labour force than in any other relatively advanced country (Crafts, 1998).

However, the First Industrial Revolution, and subsequent industrial revolutions, was nothing but swift, as the word “revolution” suggests. Each technological advance has the life of its own, and its life cycle. In the end, when an innovation has fulfilled its lifecycle, it is simply substituted with another, newer technology. This is not a smooth process. It takes time before a certain innovation is diffused.

Even the most important inventions had a very modest impact initially. The full potential developed and materialised only after the potential of a technology was explored. This was often done through using the technologies themselves and as they become cheaper and widely diffused. One example is the “social savings”. This stipulates reduction in real resource costs, and an estimate for the steam engine suggests it to be at no more than 0.2 percent of GDP in 1800. However, usage of the steam engine in terms of horsepower was 35,000 in the year 1800 and about two million in 1870. By 1870, the implications of the steam engine were fully realised and social savings went up to about 3.5 percent of GDP, excluding the larger impact of the railways (Crafts, 1998).

Young (1993) suggest that most new technologies are initially broadly inferior to the older technologies they seek to replace and are only competitive in a narrow range of specialised functions. Subsequent improvements that take place over time allow new technologies to ultimately dominate. For example, the steam engine of James Watt in 1765 was at the time crudely engineered piston, which was used mainly in the mines for pumping water. In terms of provision of power, it was not a substitute for widely used water wheel. It was after the innovations by John Wilkinson[1] in 1776 and William Murdock[2] in 1781 that the steam engine was useful for converting vertical motion into rotary force. Only after these inventions the steam engine became generally useful source of power.

The great advance of the First Industrial Revolution was not a shift from labour to capital, or new materials and machines, but rather a factory system. This system provided possibility to engage large number of workers as well as capital to work under supervision and discipline. This all required new organisational techniques and capabilities because scale of operations increased. As Landes (2003: 122) put it, “the factory was a new bridge between invention and innovation”, and goes even further to conclude that previous transformations, political or economic, had always finished by stabilising at a new position of equilibrium, while the case of the Industrial Revolution suggests an ongoing change and moving equilibrium.

The common view of the industrial revolution is as a transition in which directions and possibilities of economic life were transformed enabling dramatic demographic challenges to be defeated over the long term. The changes involved here were complex and costs were considerable, both in the long and short run. However, the progress depended on new standards of economic efficiency, i.e. productivity growth. The growth in productivity can come from changing methods or increasing resources, or, for some time, both. Whatever the case, attitudes, perceptions and understanding of production methods and opportunities were central to the process (Hoppit, 1990).

The one distinguishing, important factor for Britain at the time of the First Industrial Revolution was the partnership of inventors and entrepreneurs (e.g. Boulton-Watt partnership), which was one of the most important organisational techniques for establishment and take-off of new innovative firms (Freeman, Soete, 1997).

The analysis made by Freeman and Soete (1997) clearly shows that most of condition affecting industrial innovation in the Industrial Revolution is still relevant for success today.

Although England was on the forefront of Industrial Revolution, other industrial nations in Europe did not lag behind. In 1785 Britain was still leading, however, the lead over France in the volume of output per capita from mines and manufactures was not as significant as fifty years before. Situation with the use of machinery and large furnaces and prevalence of large privately owned enterprises is much the same as for mines and manufactures in 1785 (Nef, 1943). It is obvious that the lead of Britain was not always progressing at the same pace. Continental Europe followed the pace and narrowed the gap between the leader and the followers. It seems that the rate of economic change in France during the most of eighteenth century was not less remarkable as that of Britain.

The estimates today suggest that Britain’s trend rate of growth of real GDP growth accelerated steadily rather than spectacularly in the period after 1780. The peak was in the mid-nineteenth century at about 2.5 percent. Even though the output growth was spectacular in industries such as cotton textiles, where production techniques advanced, this was a smaller portion of the aggregate economy. This aggregate included quite a number of traditional activities, which grew quite slowly (Crafts, 1998).

However, national accounting approach cannot encompass all the elements of change of the industrial revolution. National accounts may stimulate ideas and provide very rough orders of magnitude about certain aspects of the industrial revolution. Some parts of this process can be counted, but some cannot (Hoppit, 1990).

Britain started forging ahead of France in the late 1780s. The production of iron in Britain in 1780 was around a third more than in France. In 1840 Britain was producing over three times as much. The lead of Britain came in the time of Napoleonic Wars. Similar thing happened in sixteenth and early seventeenth

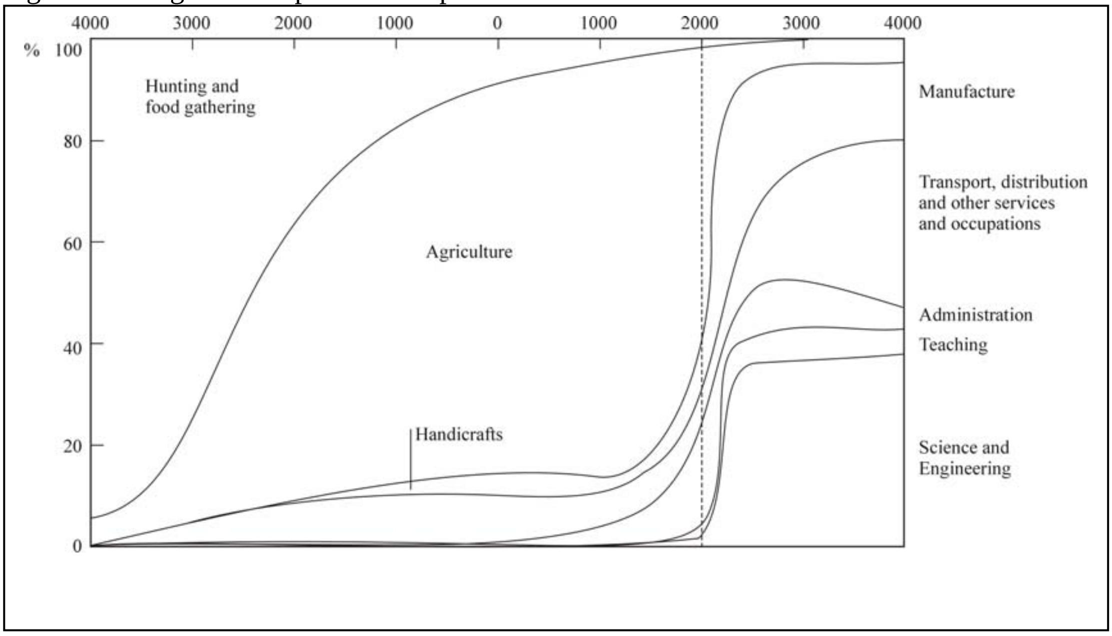
[1] John Wilkinson eliminated gaps between piston and cylinders, which have previously been stuffed with rags.

[2] William Murdock provided the sun and planet gearing system that actually made it possible to have rotary force.

century when Britain became leading European country in development of heavy industry. In this period it was the Religious Wars and the Thirty Years' War that helped Britain gain its supremacy (Nef, 1943). It should be noted further that advances in productivity were modest before the railway age. The general improvements in living standards were not experienced until 1820s. However, two effects were experienced in Britain early in comparison with other industrialised nations. These were the shift from agriculture to industry and dependence of manufacturing industry on exports (Hoppit, 1990). It is obvious how important it is to avoid destruction and draining of resources in wars for development of a country. Relative isolation of the Island was an asset in terms of development and conditions for supremacy.

Even though the concentration of technology and technology change is mostly attributing to the manufacturing industry, the technological change in agriculture was not unimportant. The agricultural productivity in Britain in eighteenth century rose but not as much as in industry. Historians even point out that mobility of labour and capital, essential to industrial growth, were made possible due to social and economic improvements in agriculture. In the countries industrialising today, especially in Asia, even though industrial sector has increased production more rapidly than agriculture, output in agriculture has a steady rise and incomes in the rural areas have improved as well. Successful land reforms in Korea and Taiwan, unlike Latin American countries, was a very significant factor in the subsequent growth and development performance (Freeman, Soete, 1997). However, agriculture as an occupation is likely to loose the role it had in last 2000 years, and before (see Figure 1).

Figure 1: Changes in occupation in the past and future



Source: Freeman, Soete, 1997: 4

The change in the structure of labour in agriculture and industry with the shift of labour from agriculture towards industry is argued to be attributed to the increase in per capita income from 1869 to 1899 in the US. It is further argued that the growth of income per capita actually reduced income share of agriculture because of low elasticity of demand for agricultural products. Subsequently this led to a reduction in the agricultural labour force. However, the predicted reduction of the share of income of agriculture was less than the actual reduction. On the other hand in years with fastest growth of income was the period in which the farm income share declined the least (Lewis, 1979).

During the eighteenth and nineteenth centuries, cotton manufacturers were combining sets of new and traditional technologies. This combination typically included steam powered spinning in factories with large-scale employment of domestic handloom weavers and a mix of powered and domestic hand weaving, long after the powered technology became available. The combination of technology was due to risk spreading, problems involved with new technologies, and the cheap labour supply of women and children. For some time, the traditional sector, and not the other way around bolstered the modern sector. The structural changes experienced in this period were largely due to the ability of agriculture to rapidly decrease its share of the labour force; thus more labour was available for industry. Furthermore, exploitation of international comparative advantage in a narrow range of goods was another significant point (Hoppit, 1990).

Even though industrial transformation was not as intense in other industries as in cotton, it can be said that it did give rise to differing experiences and social relations. Many innovations and inventions in organisation and use of labour were common to all industries and sectors. It may be further said that the industrial revolution was not merely sum of social and economic changes added up, but rather more than sum of measurable parts (Berg, Hudson, 1992).

The historical events of cluster of technological advances during the industrial revolution, especially in textiles, cannot be explained in an endogenous innovation framework. Mokyr (1990) argues that innovations associated with the industrial revolution should be seen as "macroinventions". It is suggested that these are unpredictable, exogenous shocks that lead to advances in respective sectors. The wave of these "macroinventions" in turn gives rise to learning possibilities; however these learning possibilities are exhausted over time (Crafts, 1998).

It must be said however, that "macroinventions" are very unpredictable. They are commonly generated as a result of individual genius or luck. On the other hand, "microinventions" are generated through subsequent improvement, adaptation, and diffusion of technology, commonly involving learning by doing and learning by using. Much of the productivity increases can be attributed to the later. However, "microinventions" in any given technology are subject to diminishing returns, and without periodical bursts of "macroinventions", productivity growth would lead to zero (Crafts, 1995).

It seems that technological change cannot be entirely explained either through endogenous innovation or through exogenous innovation. There is still possibility that exogenous (macroinventions) trigger off subsequent endogenous (microinventions). The example can be drawn from the textiles industry where the experts in this field strongly deny that the breakthroughs of the 1760s can be explained by demand pressure or by supply-side models (Crafts, Mills, 1997). In the Britain's situation, where technology was hard to transfer, and learning by doing and natural resources were in the spot light, seems to be the reason why the traditional neo-classical predictions do not hold (Crafts, 1998).

There are several possible factors that may have influenced low TFP growth (and R&D) in the early nineteenth century Britain. Smallness of markets, weakness of science and formal education, inadequacies of the patent system, the continued high rewards to rent seeking, and the difficulties of securing compliant behaviour on the part of workers may have contributed to the slowdown to a certain level. As far as the government is concerned, its policy did not play an active role in correcting failures nor in any other way did it intervene to correct market failures, compared to the successful government role in the Asian success stories like Korea, and Taiwan. The policy had quite the opposite role. This was viewed in the crowding out effect of public spending during the Napoleonic Wars. These financial pressures pushed for more protectionism during the eighteenth century and to rise in taxes during the industrial revolution (Crafts, 1996).

The ongoing transformation of economies after the first industrial revolution is labelled the second industrial revolution. As the first industrial revolution, the second one is continuation of development started by the first revolution. As mentioned earlier, these processes are more evolutionary than revolutionary. The innovation and inventions have emerged, but diffusion of the same is much slower process.

The beginning of the second industrial revolution is labelled with several distinctions in comparison to time before the revolution. These differences are given through three different ideas. First, the accounting got an improved role. From mere record of past events it developed into an applied science to help business decision-making. Secondly, engineers applied the results of pure science in order to get higher safety and economy in the construction of bridges and other works, and ships and boilers. The old methods, which included the rule of thumb and trial and error, were substituted with precise calculations and measurements. These new methods were of great importance in electrical engineering and slowly spread through mechanical engineering. Thirdly, there was constantly increasing competition among manufacturers and widening markets. The application of scientific ideas for the workshop along with the cost accounting represented a birth of scientific management. Taylor, by publishing his article *Principles of Scientific Management*, marked an acceleration of the second industrial revolution. There was a great movement of reorganisation in industry based on improved efficiency named "rationalisation". The rationalisation was based on preplanning of equipment and labour methods on the basis of observation and estimates found in science (Jevons, 1931).

There was an important shift here regarding the scientific methods. During the first industrial revolution much of the innovations and inventions were based on trial and error methodology, and on the rule of thumb. As economies and operations developed, this methodology was not sufficient any longer. Development of science introduced laboratories both in public and private domain. These laboratories were either merely for testing materials, or for research. Jevons (1931) distinguishes three classes of problems of laboratories. First, there was a pure science, which was usually carried out at universities and science institutes. Secondly, there was fundamental research for an industry, e.g. for cotton or steel industries. Thirdly, was the pure trade research, carried out by companies themselves in their own laboratories, the subject of examination being their own plant, materials and processes, in the light of the results of scientific and fundamental research. The problem with the later emerges when laboratories are understaffed, unable to synthesise fundamental and science research result for their own purpose. A very important distinguishing characteristic of the second industrial revolution is the professionalizing industry. Functions, e.g. administrative, technical and managerial, are clearly distinguished along with the recognition of the qualification requirements for certain positions. Furthermore, the type of an institution characteristic for the second industrial revolution is the research institute. The organisational form of such a research institute may be as a government or university department, an association, or an independent corporation.

The exploitation of technologies associated with the Second Industrial Revolution continues today. Major innovations and inventions (e.g. internal combustion engine, electricity, etc.) are still in use today with some improved features. However, main principles and ideas are the same.

The "New Economy" associated with advances in information and communication technology (ICT) is sometimes associated with transference of economies from industrial to information societies. However, advances made by using ICT are far from benefits associated with the two industrial revolutions. Up until the end of 1980s economists could see all the computers but actual benefits were hard to distinguish. The potential of ICT was made clear in 1990s. The only question is whether this constitutes an industrial revolution? Still, there is no compelling evidence that ICT could constitute the next industrial revolution. Think only would you trade the Internet (ICT) for indoor plumbing (second industrial revolution)?

Backwardness and Catch-up Process

Britain was a pioneer in the process of industrialisation, so it did not have an opportunity to catch-up to anyone. The feature of catching-up was a pronounced feature of rapid growth in Europe after the World War II. Britain of nineteenth century could not have stimulated growth through technology transfer from advanced countries for a very simple reason. Britain was on the top of technology development so all the best practices and technological advancement was already at the disposal. Furthermore, it could not evolve by evolving away from small-scale peasant agriculture, since it had already done that (Crafts, 1998).

However, even though Britain practised increased protectionism in products markets during the industrial revolution, it was certainly open and receptive to foreign ideas (Crafts, 1996). It seems that in spite of unfavourable government policy Britain managed to emerge as a technological leader. Openness to foreign ideas may well have played an important role in the process. Endogenous innovations are naturally favourable, along with the threshold of knowledge; however, new ideas do not always emerge in one country. This is a distinct advantage that Britain capitalised on, unlike some other countries (e.g. France) where acknowledgement of foreign practices took longer to take root.

When looking at the leadership position, it is a fact that the countries with fastest growth in the past one hundred years are not those who grew fastest in the preceding century. The leading countries of the Middle Ages, Brabant, Lombardy, Venice, or Dubrovnik, never regained their former position in the world as fast growing economies. The same can also be said for Egypt, which has never regained the rule over the grain trade (Ames, Rosenberg, 1963).

Abramovitz (1986) has developed the catch-up hypothesis with the US as leader and Western European countries as followers. His proposition is that in comparisons across countries the growth rates of productivity in any long period tend to be inversely related to the initial levels of productivity. It is further suggested that the width of the gap plays a role in the whole process. The larger the technological and the productivity gap between leader and follower, the stronger the potential for growth of follower countries. So it follows that the catch-up is faster for countries that are initially more backward. However, the potential for growth wears down as the follower converges closer to the leader.

But, why the success endowed Korea and Taiwan, but not the Philippines? Lucas (1993) suggests some answers to this question. The East Asian miracle countries have become large-scale exporters of manufactured goods with increasing sophistication and have become highly urbanised (not a problem for Hong Kong and Singapore) and well educated. Furthermore, high level of savings, pro-business governments, with different mixes of *laissez-faire* and mercantilist commercial policies certainly added to the effort. These are just components, which may consist of all or some parts, but are not the whole picture. If a country is advised to adopt the "Korean model" it is like advising to "follow the Michael Jordan model" in basketball. In order for these policies to be useful they should be broken down to parts in order to see how different components attributed to whole performance. It should be considered which aspect is imitable and which are worth imitating.

The advances of today's developed countries after the World War II in Europe have shown unprecedented growth performance. It is argued that this performance was due to the backlog of unexploited technology. This is particularly viewed in the light of methods already in use in the US, but not employed in Europe. Here, the US can be seen as the leader and other countries as followers. However, the initial backlog and its reduction with time cannot be a sole explanation for either speeding-up or slowdown, but it constitutes an important part.

It should be noted that the Russian iron industry in 1750 was the largest in the world. However, it was based on a charcoal technology, and as a consequence, the British who switched from charcoal to coke as fuel displaced this technology in 1790s.

In another example, some simple technical problems have not been solved for centuries, which were repetitively used. One of those is that Europeans strangled their horses with the throat and girth harness for a very long time. Only after Avar invasion the more superior trace harness was used from sixth century AD. On the other side of the world, China exhibited extraordinary technical progress up until the end of Sung dynasty in the mid thirteenth century. After that China experienced almost total technological stagnation until nineteenth century. At that time they began to imitate European technology which was superior (Young, 1993). This supports leader-follower shift hypothesis, at least to a certain extent. China today and in the last twenty years experienced an extraordinary growth. This growth is not sporadic, but seems persistent and sustainable. However, in recent years, Chinese growth has influenced world markets by the increase in demand, thus increasing prices in the world, especially for raw materials. It seems that Chinese growth is progressing too fast and may be considered unbalanced in the international sense. It should be noted, though, that China is not technological leader as it was by the mid-thirteenth century, but rather a rapid follower with vast catch-up potential.

Abramovitz (1986) attributes technological backwardness to the social conditions of a country, where tenacious societal characteristics is associated with a portion of a country's failure to achieve the level of productivity of more advanced economies. He coined the term "social capability". When social capability is incorporated, it follows that a country's potential for rapid growth is strong not when it is backward without qualifications, but rather when it is technologically backward but socially advanced.

Furthermore, the industry on European continent ("late-comers") adopted investment banking while England (early starter) never adopted it. It can be concluded that early starters develop certain level of rigidity which influences not only firms but freedom of entry as well (Ames, Rosenberg, 1963).

When a country moves from lower to higher technology level, the cost of moving from one level to another is an increasing function of the level of technology already in use. On the other hand, as country develops, the speed of development slows down as country reaches higher levels of development. This is so because changes required for advancement are more infrequent (Ames, Rosenberg, 1963).

In the case that advanced technology is largely scale-dependent, and there are further obstacles to trade, political obstacles etc., which prove to be important, large countries, will have a stronger potential for growth than smaller countries (Abramovitz, 1986).

By the beginning of the twentieth century the US took over as the industrial leader over Britain. The technological lead of the US was very real and the gap became even more substantial during and after the World War II. As Nelson and Wright (1992) argue, on the microeconomic level, the US firms were significantly ahead in application and development of the leading edge technologies. US made up the largest portion of the world trade, and overseas branches were often dominant in their host countries. Today, that is no longer the case. US technological lead has been eroded in many industries, and in some, the US is even lagging behind. There are two distinctive slices of the US dominance in the post war world. One is the dominance in the mass production, derived from favourable historical access to natural resources and single largest domestic market. The other part of the story is the lead in the high technology industries induced by massive private and public investment in R&D and scientific and technical education that the US made after World War II. Even though these investments stem from earlier institutional foundations, the leadership in this area is much the product of the post war era. However, it is sometimes argued that the strength that American companies possess is less based on technology *per se* as in the organisational efficiencies stemming from mass production and mass distribution. One of the most spectacular success stories in the US in the inter-war years was automobile industry. It was a blend of mass production methods, cheap materials and fuels. The technological leadership itself was more lasting in the industries where there was connection of mass production and organised science-based research, e.g. electrical industries and chemical engineering.

There are two views on the reasons of the US technological performance. One sees the US post- war lead as inherently transient. This is partially attributed to the late start of many present rivals, which is in accordance with the "leapfrogging" hypothesis, and in the other part it is attributed to the destruction of industrial rivals during the war. The convergence is seen here as relatively automatic and inevitable. The other view is that the US is loosing in the competitiveness to other industrialised nations. The third proposal stresses a more fundamental decline in the role of national borders and nationally based industrial centres (Nelson, Wright, 1992).

As Edgerton and Horrocks (1994) argue, in Britain before 1914, the research staff actually technically qualified in industry was just a fraction of total staff. By that time, the dominant function of scientists was not research but rather analytical control of production with a fraction of time devoted to research. However, many firms in Britain have spent a lot of money on research conducted outside their firms, before they recognised necessity of in house research departments. Furthermore, many firms employed outside consultants to carry out testing and R&D of new products before establishing their own research departments.

However, during the World War I the amount of research increased dramatically in British industry. The increase was due to the demand for products new to Britain or entirely new products. Many companies started to up-size their research potential, existing organisations expanded their operations and new laboratory units were built. Such an increase in the R&D activity during the First World War has proven to be very beneficial to the firms, which consequently strengthened R&D position within firms and further increased the funds for this purpose. In the period after the war the expansion continued in the cash rich firms. Some of these firms were in need of replacement of founding inventor-entrepreneurs. The chemical industry poses a good example. This industry was extremely R&D intensive, but this was no longer inventor-entrepreneur activity due to its size and complexity of research, which needed research laboratories and trained scientists. The British Dyestuffs Corporation, a merger between Levinstein and British Dyes, spent some £250,000 in 1919-20 for new laboratories, which employed some 80 people as research chemists. However, some downsizing of operations occurred and research staff was cut to 30 in 1923 and after that to only 15. Nevertheless, in the period 1921-4 company seems to have spent some £50,000 annually for research. However, the R&D spending in the US, in absolute terms, was some ten times greater than that of British industry in the late 1930s (Edgerton, Horrocks, 1994).

Furthermore, Abramovitz (1993) distinguishes different ways in which technology has influenced economy in nineteenth and twentieth century. The first, but not the crucial, difference is the pace of technological progress; however, the character of technological progress seems to be more crucial in this division of centuries. This may be the reason why the conventional capital accumulation has played such an important role in growth accounting for the nineteenth century and a much smaller role in the twentieth century. In the nineteenth century technological progress was heavily biased in a physical capital using direction, only to shift toward intangible (human knowledge) capital using direction in the twentieth century. This bias produced substantial contribution of education and of other intangible capital accumulation. The technological change of twentieth century tended to positively influence the relative marginal productivity of capital in terms of education and training of the labour force at all levels, from deliberately acquired knowledge through R&D investment, and in other forms of intangible capital (e.g.

support for corporate and managerial structures and cultures, development of product markets subject to the infrastructure of the economies of scale and scope). The bias shift of the twentieth century encompasses the change in employment patterns. The shift occurred from agriculture (low education levels) to manufacturing, mining and construction (intermediate education levels) to services (relatively high education levels). There are several factors that contributed to this shift. First, there was an increase in income level per capita and associated Engle effect on the structure of the final demand. Second, growths of the service industries, due to requirements of exploitation of scale intensive technological progress (e.g. trade, communications, and finance, legal, accounting and engineering professions). Finally, there was a technology bias toward agriculture and industry, where the productivity of labour was raised more than in services.

Parente and Prescott (1994) take on the argument about the barriers to technology adoption and development. They argue that for a particular firm to go from one technology level to another depends on several key factors. First is the level of general and scientific knowledge in the world and size of the barriers to adoption in the firm's country. Second, general scientific, or world, knowledge is available to all and grows exogenously. With growth of world knowledge the investment that must be undertaken to move from one technological level to another decrease. The implication of the later is that with fixed income levels and technology adoption barriers development rates increase over time. This fact is supported empirically over the last 170 years, where development rates have actually increased.

The positive definition of social infrastructure includes institutions and government policies that support incentives for individuals and firms in an economy. These incentives encompass measures as encouragement of productive activities such as the accumulation of skills or the development of new goods and production techniques. Additionally, a good social infrastructure may invoke positive indirect effects on encouragement of adoption of new ideas and new technologies as they become available in the world. According to the research provided by Hall and Jones (1998), the highest measured levels of social infrastructure is in Switzerland, the United States, and Canada. All three countries have among highest levels of per capita output in the world. On the other hand, three closest to the lowest social infrastructure is in Zaire, Haiti, and Bangladesh. All three countries have among lowest levels of output per capita in the world. Furthermore, the research concludes that countries most influenced by Europeans in the past have social infrastructure conducive to high levels of per capita output.

In explanation of persistent poverty in developing nations, Romer (1993) takes two extreme views into consideration. These views are object gap and idea gap. Object gap encompasses object like factories, roads and raw materials. Thus, countries are poor because they are lacking valuable objects. On the other hand, idea gap represents access to ideas that are used in industrial nations to generate economic value. Thus, countries are poor because citizens of these countries do not have access to ideas. Furthermore, it is possible that a developing country suffers from both gaps at the same time. Both views support the view that functioning legal system, stable monetary policy, and effective support for education yield benefits and help reduce both gaps. However, basic proposition of Romer is that idea gaps are central to the process of economic development. In the growth theory there is enough flexibility in construction of growth accounting residuals that it is possible to set the technology residual to zero. However, economic history provides knowledge of how production looked like some 100 years ago. Both these historic event and current events give support to discovery; innovation and invention have great importance in economic growth. Furthermore, goods provided by these activities are fundamentally different from ordinary objects. "We could produce statistical evidence suggesting that all growth came from capital accumulation, with no room for anything called technological change. But we would not believe it" (Romer, 1993). Another assumption of universal availability of knowledge to everybody is misleading. For example, Taiwan had no industrial base to become the fourth largest producer of synthetic fibres in 1981. The importance here lies in specific joint ventures and licensing agreements with firms from Japan and the US. Another example is India, a country with a large quantity of highly skilled human capital, where there were strict constraints on the activities of foreign firms (at least by the beginning of 1990s when India started to open up). India failed to develop industries comparable to Taiwan. With these examples in mind, "the assumption that all technological knowledge is broadcast like short wave radio transmission to every country in the world seems as inappropriate as the assumption that there has been no technological change" (Ibid.). In terms of influence of inflation on growth it can be argued that inflation has much effect on growth. However, if the idea flow from foreigners is sensitive to macroeconomic stability, and these idea flows are important for growth, than the effects of macroeconomic instability are easier to incorporate.

Conclusion

From the historical viewpoint, we can observe major importance of technology for growth and development and present levels of development. However, if the technology is the major issue, this should mean that all countries should converge to higher levels of development. Naturally, this does not hold. Historical development of countries is not one and the same. Leaders in the past are not leaders today. Britain may have been the leader, and the first country to industrialize, but that was not enough to stay on top. This ever changing role of leaders and followers is continuing historical occurrence. Furthermore, one should be patient with diffusion and wider use and benefits of invention and innovations. It takes long time for new technologies to take root, even in situations when new technologies are largely available, transferable and more productive than traditional technologies. Countries have shown a lot of rigidity to this respect, some have lost entire industries to other countries due to inflexibility.

One of the components that are attributed to fast growth of both European countries and successful East Asian countries is social capability which was in place once technology was available for transfer. In such conditions technology plays a major role in growth and development. However, if such threshold is not present technology or technology transfer is of little or no use.

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