

Techno-economic Paradigms and Latecomer Industrialization

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Summary

The interaction between the emergence of new technologies and the larger economic and social patterns of behavior are explored. After presenting a broad overview of theoretical concepts associated with technological innovation and economic progress, a description of the major techno-economic paradigms is described. The country specific paths within the broader context provided by the evolution of techno-economic paradigms are analyzed. After this general discussion, the focus goes to a specific techno-economic paradigm: the information technologies and telecommunications era, which is the dominant techno-economic paradigm at the end of the 20th century. Finally, a more speculative argument is developed around the idea that the emergence of knowledge based economies and the importance of social capital provides a more profound change than previous techno-economic paradigm shifts.

Keywords

Innovation, technological change, economic growth, industrialization.

Contents

- 1-Ideas and concepts
- 2- Empirics: Techno-Economic Paradigms and Country-Specific Trajectories
- 3- Focus on the More Recent Techno-Economic Paradigm: Information Technologies and Telecommunications
- 4- A “Meta” Techno-Economic Paradigm? The Emergence of Knowledge Economies and the Importance of Social Capital
- 5- Conclusions

1 Ideas and Concepts

The interaction between the emergence of new technologies and the larger economic and social patterns of behavior can be understood, following Schumpeter, as a process of creative destruction. At a first approximation, this statement is obvious: new technologies disrupt and often replace older ones. Thus the steam engine technology replaced animal powered means of land transportation and sailboats. At a higher level of analysis, the implications of new technologies are broader. The impact is often felt not only as a replacement of older for new technologies, but brings with it opportunities for new firms and difficulties for existing firms, the obsolescence of some occupations and shifts in the structure of employment, changes in the terms of trade between regions and countries. In other words, new technologies bring with them the conditions for the establishment of new economic conditions. On the other hand, it is clear that not all advances in technology are disruptive to the point of creating substantial changes in economic and social conditions. In fact, most technological advances and innovations make their impact felt in a relatively smooth way, when analyzed from a macro perspective.

One way to conceptualize the interaction between technological change and shifts in economic conditions is the idea of techno-economic paradigms. A techno-economic paradigm embodies a relatively stable cluster of core technologies, around which innovation and economic activity take place. The core technologies have a strong impact in the economy and society, being defined as core given their potential for generalization and penetration across a wide number of products and processes, across all sectors of economic, and often human, activity. Within a paradigm, the core technologies are virtually unchanged over time, but this does not mean that there is not economic and technological progress. On the contrary, these core technologies provide a positive heuristic that defines the knowledge and incentives for innovation and economic activity to occur. At the same time, this progress is inherently limited by the conditions set by the interaction of the core technologies with the dominant modes of economic activity, from the organization of firms, to the distribution of employment. Therefore, progress exists within a certain techno-economic paradigm, but occurs within a framework defined by a set of core technologies and modes of organizing economic activity.

Thus, within a paradigm, innovation occurs namely as the core technologies become more and more pervasive and influence ever more wider realms of production and distribution of products and services. For example, the steam engine influenced not only transportation (by land, with the railroad, and by sea), as is well known, but equally all modes of industrial production and manufacturing. Later, a new core technology, electricity, became crucial in manufacturing, but also in transportation once again, in telecommunications and, indeed, in the way it expanded the overall possibilities of hours available for production through the diffusion of electric light, to say nothing about the changes in day-to-day life.

When a major technological advance occurs, disrupting the existing core technologies and modes of economic operation, then a new techno-economic paradigm emerges.

The displacement of the core technologies of the old paradigm creates a new wave of invention and innovation and is no longer tied to the previous paradigm core technologies. The examples of the previous paragraph illustrate the shift from one to a newer paradigm. While the steam engine provided the core technology for using energy in production and transportation, the emergence of electricity displaced progressively the steam engine as the preferred mode energy provision. Note that the impact associated with the emergence of a new techno-economic paradigm is not only associated with the shift in the usage of the old by the new core technologies. In other words, it is not only the fact that factories started using electric motors and machines instead of steam engine powered instruments of production. The emergence of a new core technology requires, and creates the opportunity for, an entire new set of small and incremental innovations that permit the widespread usage of the new core technologies. Thus, when a shift in techno-economic paradigm occurs we have not only a “substitution effect”, but also an expansion of the creative frontier that allows the emergence of new technologies and enables, in the end, a shift to yet another techno-economic paradigm.

Additionally, beyond the technological and purely economic factors, the social and institutional frameworks that fit a certain techno-economic paradigm may not be adequate for a new one. Indeed, the process of emergence of a new techno-economic paradigm results from the interaction of the technological, economic, institutional and social spheres. Having just a new technology coming in may not have any effect if a set of changes in the other dimensions does not accompany the technological novelty. A certain set of institutions and social features may provide enough context for innovation within a certain paradigm; in other words, it is not necessarily needed to create institutions and social rules at the same pace that technological innovation progresses. But when there is a shift in techno-economic paradigm, a new institutional framework may be needed.

A number of authors, working together and independently, developed the theory of techno-economic paradigms. The most influential author is, naturally, Schumpeter, who argued that the expectations of profits would drive the “entrepreneur” to innovate. The entrepreneur’s drive towards innovation is motivated by the temporary monopolistic position from which the innovator would benefit. Schumpeter regarded this position as temporary because the advantages from this privileged position would eventually “perish in the vortex of the competition which streams after them”, since other firms would copy the innovator (Schumpeter, J., 1911). Schumpeter called this process ‘creative destruction’. Therefore, for Schumpeter, innovation appears at the forefront of economic progress, driving prosperity. In a later version of these same fundamental ideas, Schumpeter refined this earlier simplistic version of an entrepreneur in a perfect market composed by a multitude of competing firms that destroy any persistent market advantage. In his final work (Schumpeter, J., 1943), he acknowledged that some large corporations could sustain a market advantage by an institutionalization of the effort to innovate through the establishment of large R&D facilities.

The reinterpretation of Schumpeter's fundamental ideas of innovation as a process of disequilibrium in the broader context of techno-economic paradigm is due primarily to Christopher Freeman and his co-authors. Often called a "neo-Schumpeterian" approach, this perspective is articulated in Freeman, Clark and Soete (1982), in Freeman and Perez (1986) and in Giovanni Dosi (1988), to cite a few representative examples. Freeman and his co-authors generalized the concept of Schumpeterian innovation to the national level, making an analogy between innovation at the firm level and a change in a techno-economic paradigm at the country level. A new techno-economic paradigm is, according to Freeman (1988):

[...] a combination of interrelated product and process, technical, organizational, and managerial innovations, permitting a quantum jump in potential productivity for all or most of the economy and opening an unusually wide range of *new* investment and profit opportunities.

This macroeconomic definition of innovation corresponds to what is, at the firm level, a radical innovation. Under this extreme there are milder types of innovation, like incremental innovations, that correspond, at the micro level, to improvements in existing products and processes. Freeman builds a similar hierarchy for his macro analysis of innovation, leading to a conceptual framework that has some similarity to the evolutionary perspective of Nelson and Winter (1982).

The perspective of looking at the relationship between technological change and economic growth through the concept of techno-economic paradigms is starkly different from the neoclassical approach, which, in the late 19th century, developed the idea of a production function. Capital (machines) and labor are the side-by-side ingredients of production. Labor and capital interact in a process of production of wealth that is limited by the current level of technology. In the neoclassical literature, the accumulation of physical capital in the form of machinery and "industrial capacity" was regarded as the main driver of economic growth, and this perspective still informs much of the current policies (Easterly, 1997).

At the aggregate level, Solow (1956, 1957) showed that the pure accumulation of physical capital and labor was not sufficient to account for all the observed growth in the US for long historical periods. Solow's model assumed constant positive returns to scale, diminishing returns to each input and positive finite substitution elasticity between the two inputs. A final assumption was that technology change was exogenous. The two main conclusions of the Solow model were, first, that without technological change per capita growth would cease, and, second, that a conditional convergence would occur. This second conclusion means that countries with a lower per capita GDP would grow faster than the richer countries, a direct consequence of the diminishing returns. The major shortcome of this model was, obviously, that technological change, the main responsible for growth in the long run, was outside the model. He attributed the component of growth that went beyond the accumulation of physical capital and labor to technological change. This is an equilibrium perspective, in which resource allocation is mediated in free markets by pricing in a competitive environment.

Denison (1967) enhanced the Solow framework, arriving at similar conclusions. He analyzed long-term series of national accounts in the US, and included different potential growth drivers, in order to circumscribe what was then called the Residual Factor, the unexplainable growth of the total economy in the light of strictly traditional production factors, to its minimum size. Still, the residual, when equated with technological change, remained large, although smaller than the initial Solow estimates.

Until the 1970's there were several efforts to improve in Solow's model the treatment of technological change. As Barro and Sala-i-Martin (1995) refer:

The inclusion of a theory of technological change in the neoclassical framework is difficult, because the standard competitive assumptions cannot be maintained. Technological advance involves the creation of new ideas, which are partially nonrival and therefore have aspects of public goods.

As we saw, the work of Solow (1956, 1957) showed that the accumulation of physical assets was insufficient to account for even a small part of the observed growth. The introduction of factors such as human capital (Schultz, 1960; Becker, 1993) and technology (Nelson, 1959) to the equations attempting to account for economic growth was largely motivated by that deficiency. Denison (1967), as we mentioned before, used even more sophisticated techniques to try to circumscribe the "unexplained" component of growth. But the fundamental issue is that the roles of human capital, technology, and of the other factors proposed by Denison in promoting growth were ill understood, and the way in which these factors were introduced into models of growth reflected these deficiencies. In particular, formal models failed to incorporate the dynamics of innovation conceptualized and described by Schumpeter.

More recently, the work of a generation of economists and other social scientists has fought the tendency to oversimplify the impact of new skills and ideas on development and the conceptual framework proposed by Schumpeter has been a constant guide for theorizing about growth. The body of work of these scholars has provided sophisticated conceptual insights into the way that technology is related with economic growth (good overviews are included in Fuhrer and Little, 1996, and especially in Stoneman, 1995). The "new growth theories" are a prime instance of the effort to introduce some of those insights into the formal economic modeling framework inherited from Solow. Romer (1994) provides a non-technical overview of the main existing variants. According to Paul Romer (1990), this effort, clearly neo-Schumpeterian, can close the gap between the formal and appreciative theorists:

The first round of endogenous growth model relied on Marshallian external increasing returns and avoided explicit recognition of monopoly power. A second round of growth models subsequently made the leap to equilibrium models of monopolistic competition. [...] These second round or 'neo-Schumpeterian' models of growth with monopoly power may help bridge part of the gap between the mainstream theorists and appreciative theorists.

Nelson (1997) and Solow (1997) provide critical assessments of new growth theories from opposing perspectives. While Nelson criticizes these theoretical efforts on the basis that they do not add anything significantly new to scholarship in the area, Solow claims that new growth theory provides almost a distraction from the fundamental aspects of economic growth, which should not be concerned with modeling technological change.

Regardless of the validity of the new growth theories, very much under dispute in the specialized literature, we want to stress that there is an increased effort to incorporate the analysis of Schumpeter and many other social scientists in a coherent framework that stresses the ability to learn as the main driver of long-term growth. The origins of these efforts date back to the work of Arrow (1962), which is praised and cited as the origin of formalized efforts to account for “the ability to learn” in the context of economic development. Other examples include the work of Pasinetti (1993) that uses a modeling framework inherited from Ricardo. However, his main point is to investigate the economic consequences of human learning. The concept of economic learning also reflects the idea that some economies are able to prosper in a changing environment (Mathews, 1996), whether the origin of change is in new technology or in shifting preferences.

Coming back to the concept of techno-economic paradigm, it is important to stress two important dimensions of the techno-economic paradigm theory are “time and space”. Time is, indeed, crucial, as we saw, since the process of technological change and its economic and social impact is seen as a progress, more stable within a certain techno-economic paradigm, and very different across techno-economic paradigms, which differ over time. Space is equally important, since it is not clear that a certain techno-economic paradigm will not affect all the regions of the world similarly. Certainly there will be different rates of adoption of new core technologies when there is a paradigm shift, or even, within a paradigm, different ways in which specific innovations and modes of economic organization develop in different countries and different regions. Some countries may originate or lead the development of a new techno-economic paradigm, and others may lag behind, or even stay closer to older than the new techno-economic paradigm.

An important idea joining the time and space dimensions of the techno-economic paradigm theory is that of technological trajectories within national innovation systems. The idea of trajectories in national innovation systems (developed, with a comparative analysis across countries, in Nelson, 1991, for example) speaks to the fact that each country follows its own developmental path, within the general framework of the existing techno-economic paradigm, but also – and this is crucially important – influenced by the past history and specific conditions of the local context.

This brings to the discussion the idea of latecomer industrialization, which, in essence, refers to the concept that some economies do catch-up with the latest techno-economic paradigm later than in the countries that led or originated the new techno-

economic paradigm. The asymmetries in country performance cannot be understood merely by looking at the neoclassical models of growth. More recently, economic growth has been understood in a way that incorporates the teachings of the techno-economic paradigm concept. According to this emerging view, economic progress and technological change are understood as being dependent on what we could call with generality the knowledge accumulation through “learning” processes.

Conceptually, the foundations for the relationship between learning and economic growth are well established in the recent literature (see Bruton, 1998), and stem from a combination of the pure Solowian perspective with the Schumpeterian view. Learning is reflected in improved skills in people and in the generation, diffusion, and usage of new ideas. Likewise, organizational learning reflects social processes driven by collective cultures and appropriate management attitudes. The ability to continuously generate skills and ideas (which is to say, to accumulate knowledge through learning) is the ultimate driver of an economy long-run prospects (World Bank, 1997).

2 Empirics: Techno-Economic Paradigms and Country-Specific Trajectories

The fact that countries have different levels of income is clearly self-evident. Therefore, it is equally obvious that each country has followed its own trajectory, within the context of an existing techno-economic paradigm and the specific innovation system of the nation. We look here at some evidence on the translation of different paths in the economic performance of countries. But we begin with an interpretation of the major techno-economic paradigms, illustrated in Table 1.

Table 1- Major techno-economic paradigms and their features

Approximate Period	Description	Key Sectors	Economic Organization
1770s to 1840s	Early Mechanization	Textiles, Canals, Turnpike Roads	Individual entrepreneurs and small firms; local capital and individual wealth
1830s to 1890s	Steam Power and Railway	Steam Engines, Railway, World Shipping	Small firm competition, but emergence of large firms with unprecedented size; limited liability corporations and joint stock ownership
1880s to 1940s	Electrical and Heavy Engineering	Electrical Engineering, Chemical Process Industries, Steel ships, Heavy armaments	Giant firms, cartels, trusts; mergers and acquisitions; state regulation and enforcement of anti-trust; professional management teams
1930s to 1980s	Fordist Mass Production	Automobiles, Aircraft, Consumer Durables, Synthetic Materials	Oligopolistic competition; emergence of multinational corporations; rise of foreign direct investment; vertical integration; technocratic management styles and approaches
1970s to ...	Information and Communication	Computers, Telecommunications, Software, Digital Technologies	Networks of large and small firms based increasingly on computer networks; wave of entrepreneurial activity associated with new technologies; strong regional clusters of innovative and entrepreneurial firms

Source: Adapted from Freeman and Soete (1997: Table 3.5).

The table shows five important techno-economic paradigms. The first techno-economic paradigm corresponds to the emergence of the Industrial Revolution, as mechanization was increasingly incorporated in manufacturing, especially in some industries such as textiles. However, the technologies used within this paradigm presented some important limitations for the increase of the scale and output of the productive activity. Most firms remained small and local. Process control was poor and hand operated machines did not allow for output of reliable quality. Advances in steam engine technologies and machinery were already taking place, but it took a long time until they were ready for fruition. When these important technologies matured to the level that made their economic utilization possible, they became the core technologies of the second techno-economic paradigm. The new techno-economic paradigm based on steam engine and on machinery ameliorated some of the previous limitations, and created in itself the germ for new types of economic organization, as the table details.

If we cross the techno-economic paradigms with geography, then we start joining together the ideas of technological trajectory and national innovation system. The two first techno-economic paradigms were led by Britain. In this context, the US and Germany, for example, were “latecomers”. Still, they became leaders in the third techno-economic paradigm, with Japan also leading in the fourth and the US arguably retaining the lead alone in the fifth, although we will be looking at this claim in more detail below. Therefore, the concept of latecomer industrialization is, in itself, relative and mutable.

Still, the manifestations of the current differences in the paths followed by different countries are dramatic. Even taking a set of relatively homogeneous countries, such as the OECD, shows great disparities in income per capita and productivity. Productivity, in a way, is probably the best indicator of the extent to which a nation is taking full advantage of the conditions provided by the existing techno-economic paradigm. A recent study by Ark and McGuckin (1999) tackles international comparisons of productivity and income in a particularly careful way, especially in finding comparable measures across countries. They also link labor productivity with output per capita following a common decomposition procedure. While the relationship between these two variables may seem obvious, in fact there are many subtleties involved. For example, a country that is very productive but where workers engage in productive activities fewer hours than a less productive country can result in a higher output per capita in the second country. Table 2 shows the results presented in this work. Column (1) indicates labor productivity and column (8) provides the level of GDP per capita.

Table 2- Decomposition of GDP per Hour Worked into Effects of Working Hours, Labor Force Participation and GDP Per Capita, 1997

	GDPper hour worked as a % of the OECD Average	Effect of working hours	GDPper person employed as a % of the OECD Average	Effect of unemployment	Effect of labor force as a % of the working age population	Effect of working age population as a % of the total population	Total effect of labor force participation	GDPper person as a % of the OECD Average
	(1)	(2)	(3)=(1)+(2)	(4)	(5)	(6)	(7)=(4)+(5)+(6)	(8)=(3)+(7)
Australia	96	0	96	-1	2	0	1	97
Austria	102	-4	98	3	-2	1	2	100
Belgium	128	-5	123	-3	-19	-1	-22	101
Canada	97	2	98	-2	2	2	2	100
Denmark	92	0	92	1	9	1	11	103
Finland	93	0	94	-7	2	0	-5	88
France	123	-9	113	-6	-9	-2	-17	97
Germany	105	-5	100	-3	-4	2	-4	96
Greece	75	-4	71	-2	-11	1	-12	58
Ireland	108	5	113	-4	-12	-3	-18	95
Italy	106	-11	96	-5	-1	2	-5	91
Japan	82	10	92	4	6	4	14	106
The Netherlands	121	-26	95	2	-4	2	0	96
New Zealand	69	8	77	1	3	-1	2	79
Norway	126	-17	109	4	12	-4	12	122
Portugal	56	2	58	0	1	1	2	60
Spain	84	13	97	-14	-13	2	-26	71
Sweden	93	-3	89	-3	6	-4	-1	88
Switzerland	94	0	94	3	12	1	17	111
Turkey	36	2	38	0	-8	-1	-9	29
United Kingdom	100	-9	91	0	3	-2	0	92
United States	120	-1	118	3	9	-2	10	128
EU-14	103	-5	98	-4	-4	0	-8	90

Source: Ark and McGuckin (1999). Summations may not add exactly due to rounding errors.

Portugal and Turkey have the lowest hourly labor productivity rate of the OECD. Portuguese hourly productivity is about half of the OECD average. Productivity in Greece is 19 points above Portugal's and Spain's productivity is 28 points above the Portuguese hourly labor productivity. Still, when one looks at column (8) Greece's GDP per capita is actually lower than Portugal's by two points and Spain's GDP is only 11 points above Portugal's.

The decomposition of the table shows the variety of effects involved. Column (2) shows the impact of the number of hours worked. The summation of columns (1) and (2) produces the GDP per person employed. We see that Spanish and Japanese workers work longer hours than in most of the other countries. Per worker productivity in Spain, measured as GDP per worker, raises almost to the OECD level. Portuguese workers also work long hours, adding 2 points to the per hour productivity measures. In Italy, France, The Netherlands, Norway and the United Kingdom less hours of work reduce per employee productivity. Standards of living are determined not only by the number of hours worked and the productivity of each hour of work, but also by the "number of mouths to feed". The effect of the labor force participation connects per worker productivity and GDP per person. It is the effect of the labor force participation, for example, that brings down the income per capita of the productive and hard working Spanish workers: the combined effect of unemployment and the low level of labor force in the working age population take 26 points to the per worker productivity. The same happens in Greece, where 12 points are taken to the per worker GDP. In Portugal, both the effects of hours worked and labor force participation are small and positive. It is, therefore, clear that the real challenge to increase the level of GDP per capita in Portugal is not so much a reduction of unemployment or, more generally, an increase in labor force participation (as in Spain, for example), but that it is really the increase in the fundamental hourly labor

productivity. To understand these differences it is important to look at the existing dominant techno-economic paradigm, to which we will now turn.

3 Focus on the More Recent Techno-Economic Paradigm: Information Technologies and Telecommunications

The advent of new digital technologies has captured the minds of businessmen, policy-makers and many academics alike. The computer, new telecommunications devices and, more recently, the Internet are, indeed, powerful and impressive technologies. They are affecting people and firms in fundamental and permanent ways. There is a sense of unprecedented opportunities for many firms and individuals, confronted with technologies that enable new venture creation with relatively few barriers to entry and possible quick and huge financial gains. For existing firms, these new digital technologies are being equally perceived as providing ways to increase efficiency and market reach. As successful Internet start-ups, such as Amazon.com, and their promoters work as role models for firms and individuals, Silicon Valley and other poles of technology-driven economic prosperity inspire regions across the world.

At the country level, USA is considered the benchmark against which the generation and adoption of digital technologies by other countries and regions is to be measured. An OECD (2000) report provides several measures of USA's dominance in information and communications technologies. The USA accounts for about 36 per cent of the world production of these technologies, and the share of patents and innovations in these technologies is substantially higher. The USA has equally 50 per cent of the world's software market. NUA Surveys (www.nua.com) estimates that about half of the world's Internet users live in North America. According to the estimates of the US Department of Commerce (1999), between 1995 and 1998 information technology-producing industries accounted for an average of about 8 per cent of the GDP of USA, but were responsible for 35 per cent of the GDP growth rate. Estimates by Hecker (1999) put the share of broadly defined high technology employment (which is dominated by information technologies and telecommunications) at 14 per cent.

Within this context, it is not surprising that many countries, regions and cities around the world are trying to catch the wave of the Internet and of digital technologies. By most accounts, the achievement of regional economic development based on new information technologies results from a combination of efforts from the private and the public sector. Recently, public officials and decision-makers have been heavily pushing the development of initiatives geared towards the enhancement of the conditions that can lead to IT-driven prosperity. The European Commission, for example, through his Commissioner for Enterprise and the Information Society, said in a recent speech: "Europe is in the middle of an economic revolution. This is the time for a call for action to both the private and the public sector in Europe. We must

work for a strong European e-economy which realizes electronic services for the benefit of all”¹.

While USA took the lead in the development and diffusion of digital technologies, and especially in finding and promoting ways to derive economic benefits from its usage², Europe is now catching up fast. By any measure, digital technologies are not as diffused and are not used with the intensity that occurs in USA, with the exception of mobile phones. But the growth rate in Europe is attracting investors and creating a boom that does compare with the one that the USA has gone through in the last few years (see **Cornet, Milcent and Roussel, 2000**). Kramer and Simpson (1999) estimate that Western Europe has more than 30 per cent of the world cellular phone market, with North America having only 20 per cent.

The impact of the digital technologies is expected to extend much beyond improving the economic performance of economies. Their impact is said to be creating an Information Society, justifying the title of the European Commissioner responsible for the promotion of the use and creation of digital technologies in Europe. In Portugal there is equally an important government initiative oriented towards the development of the information society. The National Initiative for the Information Society aims to achieve four broad objectives: to create a more open state, to link and make available to all the available knowledge, to promote Internet usage in education, and to support and develop digital technologies usage by firms.

Nobody could deny that digital technologies are important and are, indeed, changing the way people and firms interact and work. They are providing new ways to access to information and entertainment. Still, the question remains on whether digital technologies are indeed the chimera for development and growth that many seem to believe. From a macroeconomic point of view, fundamental changes associated with technology should be visible in increases in productivity. While digital technologies may have indeed made many millionaires and billionaires the world over, as well as improved the efficiency of many firms, the real question is whether the benefits have been entirely internalized by the producers and users of technology or, in contrast, if there were spillovers that translated into structural improvements of the economy.

A White House conference on the New Economy held in April of 2000 revealed the range of opinions that circulate in the country³. A recent convert to the “new economy” hypothesis is Alan Greenspan, who said at this conference⁴:

¹ Cited in Cordis Focus, March 13, 2000. Cordis is available at www.cordis.lu.

² In reality, two European researchers at CERN, the large European research lab for particle physics, invented the World Wide Web.

³ See <http://www.whitehouse.gov/WH/New/html/20000405-a.html>.

⁴ See <http://www.pub.whitehouse.gov/uri-res/I2R?urn:pdi://oma.eop.gov.us/2000/4/6/5.text.1>

While there are various competing explanations for an economy that is in many respects without precedent in our annals, the most compelling appears to be the extraordinary surge in technological innovation that developed through the latter decades of the last century. In the early 1990s, with little advance notice, those innovations began to offer sharply higher prospective returns on investment than had prevailed in earlier decades. The first sign of the shift was the sharp rise in capital investment orders, especially for high-tech equipment, in 1993. This was unusual for a cyclical expansion because it occurred a full two years after the trough of the 1991 recession.

Most skeptics on the validity of the new economy hypothesis are academic economists, especially those that devote their efforts to empirical work. For example, Jorgenson and Stiroh (1999: 110), in an empirical assessment of the relationship between information technologies and economic growth, write: “We conclude that the story of the computer revolution is one of relatively swift price declines, huge investments in IT equipment, and rapid substitution of this equipment for other inputs. Perhaps more surprisingly, this technological revolution has not been accompanied by technical change in the economic sense of the term, since the returns have been captured by computer producers and their customers.”

Robert Gordon (1999) looked at the evolution of output per hour in USA since the 1950s. The study looked at the rates of growth in productivity in three periods. The first period, from 1950 to 1972, is considered the post-WW II Golden Age of productivity growth. Then, from 1972 to 1995, comes the productivity slowdown. Finally, from 1995 to 1999 comes the era of the so-called “new economy”.

Looking first at the line for the annual growth rate in productivity in non-farm private businesses, the three periods are markedly different. During the Golden Age (column (1)) productivity increased at an average growth rate of 2.63 per cent per year. In the next period (column (2)) the growth rate decreased to 1.13 per cent, and thus the slowdown period. Finally, since 1995 productivity growth picked-up in the USA, and grew at 2.15 per cent a year. The values for manufacturing reveal a slightly different story. In fact, the productivity growth rate was approximately the same during the Golden Age and the Slowdown: approximately 2.5 per cent a year. However, productivity growth in manufacturing almost doubled during the recovery, reaching an annual average growth rate close to 4.6 per cent. It was in the services that the productivity slowdown was more severe.

Table 3- Percentage Average Annual Growth Rates for Productivity (Output per Hour Worked) in the US, by Sector for Different Intervals, 1950-1999

	Q2 1950 - Q2 1970	Q2 1970 - Q4 1995	Q4 1995 - Q1 1999	Slowdown	Recovery	Recovery/ Slowdown (%)
	(1)	(2)	(3)	(4)=(2)-(1)	(5)=(3)-(2)	(6)=(5)/(4)
Non-Farm Private Business	2.63	1.13	2.15	-1.50	1.02	-68.0
Manufacturing	2.56	2.58	4.58	0.02	2.00	10000.0
Durables	2.32	3.05	6.78	0.73	3.73	511.0
Computers	-	17.83	41.70	-	24.22	-
Non-Computers	2.23	1.88	1.82	-0.35	-0.06	17.1
Non-Durables	2.96	2.03	2.05	-0.93	0.02	-2.2
Non-Farm non-Durables	2.68	0.80	1.50	-1.88	0.70	-37.2

Source: Gordon (1999: Table 1).

However, the most remarkable result from Gordon's study is the realization that the manufacturing productivity recovery is extraordinarily concentrated in a single small sector of the US economy. First, note that there has been hardly any recovery in the productivity of non-durable manufacturing (the annual growth rate remains around 2% since 1995). The recovery does exist in the durable manufacturing sectors, where the annual growth rate more than doubled from 3 per cent during the slowdown period to 6.8 per cent during the recovery. But if we probe even at a lower level, we can see that all of this increase in productivity is accounted for a single sector: computer manufacturing. Non-computers, again, exhibit similar productivity growth rates in the slowdown and recovery periods (about 1.8%).

There have been mostly two interpretations of Gordon's results. The first, largely advocated by Gordon himself, is that the "new economy" conjecture has been overhyped. In particular, he argues (in a different work, Gordon, 2000) that digital technologies are not comparable, in their social and economic impact, to other inventions with roots in the 19th century (such as electricity, the internal combustion engine, among others). In particular, the Internet, while clearly increasing the welfare of people, does not necessarily increase the economy's productivity. This rather skeptic view on the benefits of the Internet and of digital technologies entails a somewhat pessimistic outlook concerning the prospects of the benefits of the "new economy" in Europe. In essence, the argument is that the huge productivity gains are confined to the IT producing firms, sectors and countries. In other words, the countries that are mostly users of IT will benefit less from digital technologies than those countries that produce IT.

However, there is a more optimistic view. The fundamental question to be asked is that if computer associated firms can benefit from IT technological advances, why should not firms in other sectors do the same? It may take some more time for these benefits to reveal themselves statistically in other industries, but eventually a spill over to other industries is likely to arise. As we discussed above, anecdotal evidence already suggests that digital technologies are gaining momentum in terms of their economic weight and in the changes they are driving in people and firm's behavior. According to some, the computer and its associated digital technologies are part of a regime transition, following the pioneering formulation of Freeman and Perez (1986).

This hypothesis suggests that the emergence of a new radical technology requires a number of minor technological improvements, as well as institutional and social adjustments, to make its impact noted in the economy. In a word, the emergence of a radical technology requires time. Historical analysis proposed, among others, by Paul David (1990) show that previous important technological breakthroughs took decades until they had a measurable economic effect. In his 1990 work, Paul David focused on the substitution of electric motors for steam engines, and established a historical equivalence with the computer. More recently (David, 2000) he suggests that the same type of “delaying” mechanisms is at work today with digital technologies and the Internet.

This understanding of the relationship between digital technologies and economic performance has two important implications. The first is associated with the acknowledgment that a major technological breakthrough needs many minor technical advances beyond the technological frontier to make the technology economically useful. In particular, the technological frontier often needs to be customized to the unique demands of users and investors in particular places and contexts. Bresnahan and Trajtenberg (1995) call these “customization innovations” co-inventions. Therefore, these localized co-inventions are, in the end, the engines of economic growth at the local level. Consequently, different countries may have considerable different paths in the production of co-invention. Some will be able to take advantage of the emergence of a technological breakthrough and to produce a number of co-inventions that can lead to a preeminent position in certain segments. That seems to be the, to a large extent, the history of Finland in cell phones. The technologies that made the cell phone possible were not invented by the Finish, but they were still able to co-invent with enough vitality to impose their products worldwide.

The second implication of the Freeman-David understanding of the relationship between digital technologies (or technological breakthroughs, more generally) and economic performance is that the process is not policy neutral. In fact, David (2000) writes: “a new general purpose technology requires the development and coordination of a vast array of complementary tangible and intangible elements: new physical plant and equipment, new kinds of workforce skills, new organizational forms, new forms of legal property, new regulatory frameworks, new habits of mind and patterns of taste”. Given this context, David concludes later that a translation of a new technological breakthrough into better economic performance “is not guaranteed by any automatic market mechanism and that it is foolish to adopt a passive public policy stance and simply await its arrival.”

We have been focusing primarily on digital technologies, for reasons that should be obvious by now. Many see in the evolution of information technologies the foundation for a “new economy”. As a first approximation, it is clear that digital technologies are not the only ones that are having an economic and social impact. Other areas, such as the life sciences (biotechnology included) and health have seen dramatic improvements over the last few years. A still broader point is associated with the increasing importance of knowledge. The emergence of “knowledge-based economies” is, in fact, a larger concept than the one associated only with digital

technologies and the Internet. This may be, indeed, a stronger idea than that of only just a techno-economic paradigm, but also a profound change in the way well being, wealth and prosperity are generated and sustained. We look at this hypothesis below.

4 A “Meta” Techno-Economic Paradigm? The Emergence of Knowledge Economies and the Importance of Social Capital

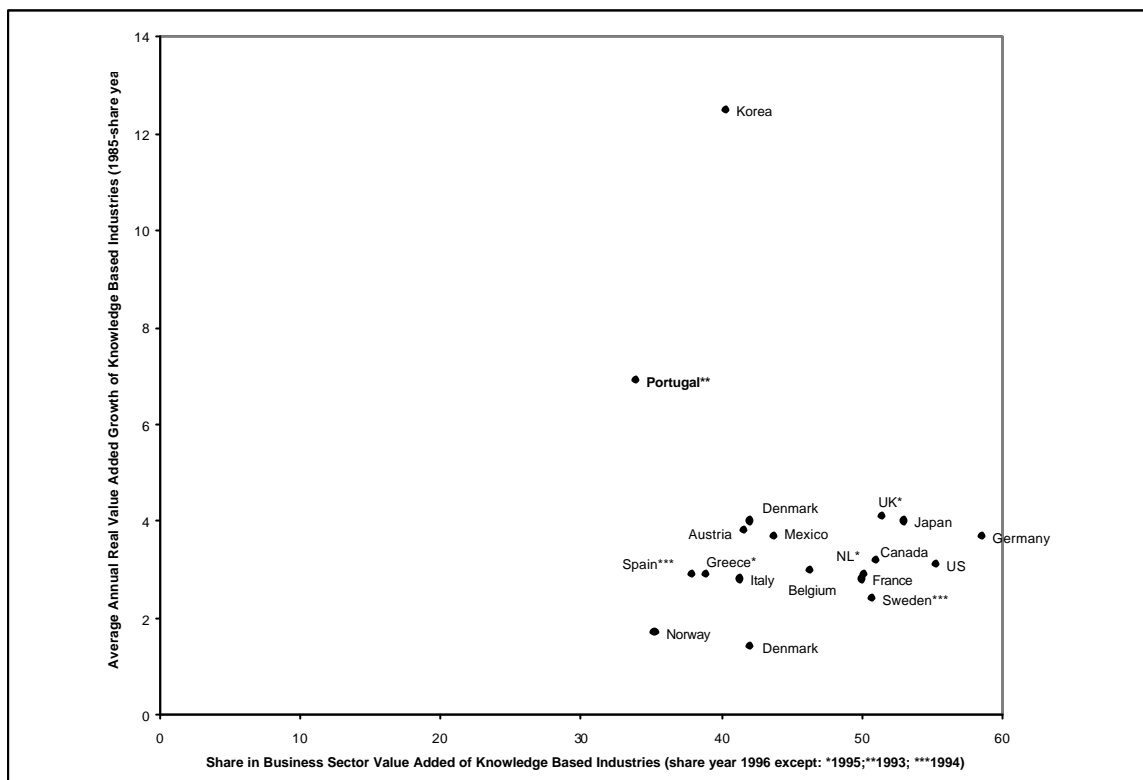
Looking at the steady improvement of living conditions along the 20th century, it is clear that knowledge has been playing an increasingly important role (see Johnson, 2000, for a summary perspective, and Landes, 1998, for a broader treatment). Recent models of long-term economic growth have been able to explain the increase in per capita income in developed countries with extremely parsimonious models based exclusively on the growth of knowledge. The factors behind the increase of knowledge are equally simple: the increase in population and the emergence of specialization in the production of knowledge. Kremer (1993) uses a model exclusively based on population growth, where more people means that there are more individuals capable of making a significant discovery and that the larger the population the larger the benefits from those discoveries. In other words, technological improvements make population growth possible which, in turn, creates more possibilities for new discoveries. A slightly more complex model by Hall and Jones (1999) includes also the effect of the specialization of growing proportion of the population in activities associated exclusively with the creation and transmission of knowledge. This entails the need to include institutions and policies –a combination that the authors call social infrastructure – which, according to this model, explain difference across countries in their level of knowledge generation and income per capita.

The gradual transition towards knowledge-based economies has intensified in the last part of the 20th century. According to the OECD (1999) more than 50 per cent of the OECD countries’ GDP is associated with knowledge-based industries⁵. Lundvall (2000) asserts that the intensity of the acceleration of knowledge creation and diffusion requires a more dynamic characterization. In Lundvall’s opinion, we should speak about the emergence of a learning society.

In this context it is important to look both at the *level* of the measures that indicate the extent to which a country is engaged in the knowledge economy and to the *growth* in recent years. Figure 1 provides a first illustration, with the horizontal axis representing the intensity of knowledge-based industries in the mid 1990s and the vertical axis the growth rate of these industries in the previous decade.

Figure 1- Knowledge Based Industries Intensity and Growth

⁵ Even if the definition of knowledge-based industries is rather generous, including a large part of services and the high and medium-high technology manufacturing.



Source: OECD (2000).

Most countries are clustered at the bottom of the figure, with growth rates between 2 and 4 per cent a year. The horizontal distribution of the countries shows Germany, the US, Japan and other leading developed countries to the right, with Spain and Greece to the left. In this context, Portugal and Korea stand out. The intensity of the knowledge-based industries in these countries is relatively low, especially for Portugal, which has the lowest level of knowledge-based industries. However, the growth rates for Portugal and Korea are remarkably higher, with the knowledge based industries in Portugal growing close to 7 per cent a year, and Korean knowledge based industries at more than 12 per cent a year. The rate of growth of knowledge-based industries in comparable periods was of 3.1 per cent for the European Union and of 3.5 per cent for the entire OECD. The difference between the growth rates of Portugal and Korean is not as extraordinary as it may seem. In fact, the business sector as whole rose in Korea at 9.1 per cent a year, while in Portugal the growth rate of the entire business sector was 4.6 per cent. Consequently, the difference between knowledge-industries growth rate and the entire business sector growth was of 2.3 per cent for Portugal (or 50% of the business sector growth rate) while in Korea the difference was 3.4 per cent (a higher difference, but only 37% of the entire business growth rate). The case of Portugal and Korea are relevant because they are illustrative of latecomer industrialization and may represent indications of the process through which these latecomer countries become engaged in the new techno economic paradigm.

The performance in this knowledge-rich competitive environments to a large extent depend on the quality of human resources (their skills, competencies, education level, learning capability) and on the activities and incentives that are oriented towards the generation and diffusion of knowledge. In this regard the Portuguese situation is clearly deficient. We will first look at some indicators associated with the quality of human resources, and then at others associated with knowledge-generation activities.

According to the **OECD (1998)**, Portugal has, after Turkey, the lowest share of the population aged 25-64 with at least an upper secondary education level. This share is about 20 per cent for Portugal, while the OECD average is three times larger, at 60 per cent. In the USA it is 76 per cent, in Finland it is 67 per cent and in Ireland it is 50 per cent. It is, however, important to note that the deficiency is not so much in the case of university or tertiary education. While the share of the Portuguese population with university education is also low (about 7%), it is only about half of the OECD average, and is comparable to that of countries such as Italy and Austria. Portugal is characterized largely by a “dual” system, with a small share of the population with university education (but not that much smaller than in other countries) and an equally very small share of the population with education levels between university and upper secondary (inclusive).

Equally problematic is the flow of graduates in science and engineering, measured as the percentage of the labor force. In the mid 1990s the European Union average of the share of graduates in science and engineering was around 0.12 per cent. Countries such as USA had shares equal to the EU average, and Ireland had a share more than double the European Union average, at 0.25 per cent. In 1996, the value for Portugal was only 0.03 per cent (**OECD, 1998**).

Equating the quality of human resources with educational levels is, clearly, an incomplete characterization. Still, it is reasonable to expect the educational level to be associated with the quality of human resources and with human capital. But beyond human capital, which corresponds to the aggregation of an individual capacity for knowledge accumulation, developing a collective capacity for learning – as suggested by Wright (1999) in the context of USA is as, if not more, important than individual learning. Instead of individual or even aggregated human capital, a further important concept for learning seems to be the social capital. The importance of social capital, while still controversial, is increasingly being seen as an important determinant of economic performance and, especially, of innovation and creativity. The relationship of social capital for the economic performance of nations was recognized by Olson (1982) and North (1990), in broad descriptions of the process of development, and was framed explicitly in terms of social capital by Putman (1993). Bruton (1998:904) wrote: “There is increasing doubt that growth is as simple as it appears in [simple] arguments, and renewed emphasis is being placed on more basic characteristics of an economy, especially entrepreneurship, institutions, and knowledge accumulation and application.”

The next question is, then, to find out what are the determinants of social capital. Glaeser (2000) suggests that education is strongly associated with social capital,

which indicates that an important component of policies aimed at increasing social capital necessarily needs to go hand in hand with policies aimed at increasing the educational level. The reason is not only the fact that there is an association between human and social capital, but also the fact that being in school provides a context for social interaction and learning that has important spillover effects in strengthening social relationships and networks. Alesina and Ferrara (2000) confirm the important role of education as a determinant of social capital, but show also that beyond individual characteristics, the characteristics of the community are equally important. These characteristics include dimensions associated with the way people compare themselves with each other, such as income inequality.

As we saw above, development is increasingly understood as a combination of learning processes, at all levels: individual, organizational, and national. Thus the issue is to try to understand why and how some people, firms, and countries learn, while others do not. Diversity and heterogeneity across individuals and countries will always surely entail some level of inequality in learning performance. Still, the dimension of the gaps and the size of the world inequalities warrant a search on the reasons why some do learn so well, while others seem to lag, even acknowledging for the idiosyncrasies that will always lead to some differentiation across individuals, organizations, and countries.

When focusing on regional and national learning, the first question to address is who are the actors of the learning processes and how is the knowledge that is accumulated translated into practical implementations over time. As we suggested above, learning at the aggregate level of a region or country is likely to depend on many types of learning at different levels, from people to organizations. One simple way to address the question is merely to say that regional or national learning reflects individual and organizational learning. In other words, when a region accumulates knowledge, this is the result of the aggregation of all the knowledge detained and produced by individuals and organizations in that region. Thus, in growth models, “human capital” is a proxy for this individual capacity for learning, normally measured at the national level by aggregating performance in educational attainment and skills, when the latter can be measured.

But the key to regional learning goes beyond the mere aggregation of this individual capacity for knowledge accumulation. It entails “collective learning”, as suggested by Wright (1999) in the context of USA, which means more than just individual learning, or learning within the boundaries of an organization. Regional learning also incorporates, not just an individual inventor or a single creative company, but the idea of “collective invention”. Instead of individual or even aggregated human capital, the key for regional learning seems to be “social capital”.

The usage of the term “social” entails that we are moving beyond a mere “economic” analysis, used in the sense of a market with rational actors where transactions and interactions are mediated by self-interest through prices. In other words, for a market system to function well, the country or region must have embedded a set of social

capabilities that allow it to function according to the principles of allocative efficiency.

More recently, the importance of social capital has been realized by students of the process of transition of former socialist countries, an important issue in terms of the concern with inclusive development. Eager to enter the world of democratic market economies, most of these countries embarked on privatization and promotion of competition. But as has become increasingly clear, the underlying social conditions and institutions for these new markets to function properly just were not there. Stiglitz (1999) reviews the ten years since the transition to market economies emerged, analyzing the process in the context of development economics. With some exceptions, such as Poland and Slovenia, most economies in transition are today worse off (in terms of GDP) than they were ten years ago. Georgia lost almost 70 per cent of its GDP, the Russian Federation almost 50 per cent and the Slovak Republic, a relatively good performer in this dire context, about 5 per cent. Imposing a market system without redefining the proper role for the state and without guaranteeing the resources for the state to gather resources to comply with its mission (through just and enforced tax laws), just to mention a critical failure of the transition so far, dramatically hampered the process.

Cast in this light, the problem of development, and the meaning of learning, goes much beyond the accumulation of capital and technology. It is not so much that fast cars, electrical energy, computers and the Internet are not available, say, in Russia; it is the lack of “social capital” that impedes the Russian people to be included in the process of development.

Social Capital has also been brought into the polemic over the explanation of the stellar economic performance of East Asian nations since World War II. The explanation of the growth of East Asian countries has been riddled with a controversy over what was more important: the accumulation of factors of production (human and physical capital, primarily) or gains in efficiency through the adoption of new technology. The polemic started with **Young (1995)**, who showed that capital accumulation could account for most of the economic growth of the high-performance Asian countries. **Krugman (1994)** also argued that these countries were repeating the experience of the Soviet Union in the 1950s, and that no long-term growth would be sustainable, since the adoption of new technology was minimal.

However, the explanation for the success of the Asian economies has to be probed at a deeper level. **Rodrik (1997)**, in an innovative analysis of the economic performance of the East Asian Tigers, where he looked at differences in the performance among countries, found that the key issues that explained the diversity in performance were associated with what he called “institutional quality”. Short of using the term social capital, Rodrik defined institutional quality in terms of four key factors: the quality of the bureaucracy; rule of law; risk of expropriation; and repudiation of contracts by government. Coupled with differences in initial levels of income and education, Rodrik shows that a combined index of those four factors accounts for all the differences in growth performance among the East Asian countries.

The issue of social capital (or lack thereof) is relevant even in the poorest countries. In fact, it may very well be in these countries that more urgency exists in terms of the need to increase social capital. In the poorest countries, even a small increment in social capital can have a huge impact in the way other investments in education and technology translate into economic development. Freeman and Lindauer (1999) make precisely this point in their analysis of the economic stagnation of sub-Saharan Africa. These authors claim that standard explanations for this dismal performance – such as lack of education, lack of openness to trade and to foreign capital, and urban bias – are, as they say, not compelling. The same goes for more traditional reasons, such as climate, geography, and ethnic fractionalization. Freeman and Lindauer argue that lack of political stability, failure to secure property rights, corruption, and dictatorship are some of the factors for backwardness of Africa. They suggest that it is essential for Africa to establish an institutional environment that allows individuals and organizations to gain the returns from their investments. In other words, Africa needs social capital.

We now move towards a conceptualization of the concept of human capital that is intended to be useful to suggest science and technology policies. Putman (1993) was one of the firsts to use the idea of asymmetries in the “endowment” of social capital to explain divergent patterns of development. Contrasting the development of North Italy, rich and sophisticated, with Southern Italy, impoverished and backward, Putman developed an argument whereby he explained the superior development in the North in terms of its superior endowment of social capital. For Putman, social capital reflects the complex web of personal and institutional relationships based on trust and shared concerns and objectives. These relationships created “networks of civic engagement” that create conditions for effective politics, efficient markets, and enhanced production and distribution of output. These networks of civic engagement resulted from frequent and strong interaction of people in many organizations and activities, beyond the normal professional context, leading to a rich and dense social community. Trust is pervasive in personal, business, and political interaction, since neighbors know and care about each other.

The usage of the expression “endowment of social capital” is particularly appropriate, in our opinion, to characterize Putman’s perspective. He finds that the roots of the high levels of social capital in the North can be traced to the 11th century. That was when the Northern Italy’s political and social organization was dominated by communes, which then led to many city-states, while the South was dominated by an autarchic single ruler who extended his power over a large region. Thus, North and South entered different development paths that self-reinforced, in the case of the North, the creation of social capital, and in the South, its virtual absence. Thus, regions “endowed” with social capital, as they may be endowed with natural resources such as oil or a fertile land, will do well. Those that do not have this endowment will have to “learn”, through trial and error, how to create their own level of social capital over time.

Recent studies have suggested an optimistic view, one where policy can indeed influence the development of social capital. Cohen and Fields (1998) analyze the

explosion of Silicon Valley in the second half of the century in the light of the accumulation of social capital. They point out that social capital in Silicon Valley is *different* from that of Putman’s northern Italy. In Silicon Valley, people do not know each other and they do not interact socially as the Northern Italians did. As these authors put it, Silicon Valley is a world of strangers, of sparsely distributed houses and impersonal strip malls. It is a world of people without roots in the region, who arrived from the Four Corners of the world and from across the USA. Rampant individualism, rather than generous sense of community, characterizes Silicon Valley.

But, nonetheless, Silicon Valley has its own sort of social capital. It consists of collaborative partnerships driven by self-interest of individuals and organizations focused on innovation and being competitive. It is still influenced by history, but a much more recent one than Putman’s millennial perspective. The almost legendary story of Stanford’s Dean Termin with his former students Hewlett and Packard defined the context for a new type of relationship between universities, entrepreneurship, and financing. Exogenous national conditions, such as the post WWII industrial and defense policies of USA, provided both funding and demand for high tech products that fueled the development of new industries. Institutional inventions, such as rewarding employees with stock options rather than salaries and wages, permitted the growth of a wave of new small, but highly innovative, firms. The “social glue” in Silicon Valley is largely aided by legally binding formal contracts, rather than trust and informal sentiments of respect and sense of community.

The discussion of these studies indicates that probably there is not a single type of social capital. Table 4 summarizes the differences in social capital in Northern Italy and in Silicon Valley. Despite the differences, it is worthwhile to note the common structural aspects that are key to having social capital. Since social capital depends on connections and relationships between people and organizations, the concept of “network” emerges as fundamental.

Table 4- What Type of Social Capital?

	Generic Description	Type of Networks	Type of Relationship
North Italy Putman (1993)	Dense civil society leading to a rich social community	Networks of Civic Engagement	Informal, familial and communal trust
Silicon Valley Cohen and Fields (1998)	Collaborative partnerships for innovation and competitiveness	Networks of Innovation	Legally binding formal contracts

Networks are glued together and acquire a life of their own depending on the “relationships” that exist among people. These relationships can be informal, such as

in Italy, or largely formalized, such as in Silicon Valley. Other types of relationships structuring networks exist. For example, in socialist countries it can be argued that there were centrally established and controlled networks that coordinated the interactions among people. The abandonment of those networks in favor of a mythical conceptualized market led to the problems described in subsection 2.2 when we discussed the transition problems of the formerly socialist countries. Stiglitz (1999:9) quotes a colleague saying: “the institutional blitzkrieg destroyed without replacing the old social norms – removing the last restraints against society-threatening levels of corruption. This is like a flame-thrower to burn-off an old coat of house paint, and then lamenting you couldn’t finish the new paint job because the house burned down.” These relationships or social norms structuring the networks can be thought as “institutions”, understood as the social system that encompasses these networks. The term “institutions” is used here in the sense suggested by North (1990), understood as “any form of constraint the human beings devise to shape human interaction”. Institutions can be either formal (laws and regulations, for example) and informal (conventions and codes of behavior, to name a few). *Networks* of people and individuals are created and evolve within the context of the incentive structure and constraints imposed by a specific set of *institutions*.

5. Conclusion

To summarize the discussion so far, we have established that national or regional learning depends on the existence of social capital, which is defined by networks and by institutions. Institutions govern the interactions among the nodes of the networks, be the nodes composed of people or of organizations (firms, universities, and local government, for example). The behavior of networks exhibits well-known properties, such as large externalities and path dependence. **Marshall (1920)** analysis is cited as the first analytical treatment of the consequences of localized networks externalities for development. Key to Marshall’s idea is the concept of external economies of scale, or what we could call in our terminology regional learning. In fact, Marshall argued that economies of scale were not restricted to a single firm, but rather that several firms concentrated in one industry and in one location could take advantage of access to specialized suppliers, skilled labor, and innovation spillovers. Thus, these external economies of scale provide incentives for firms to cluster and to agglomerate, leading to a local industry-specific economic vibrancy not unlike the one that exists today in Silicon Valley. These incentives further strengthen the cluster, leading to increasing returns and path dependence.

Extending this idea, Wright (1999: 296) defends that this type of regional learning occurred also at the national level in USA in the aftermath of the Industrial Revolution in North America. Thus, the reach of the spillovers and the characteristics of the learning network were countrywide: “American economic growth in the nineteenth century did entail learning, and this learning was substantially a national network phenomenon.”

Still, Marshall analysis help us to understand the workings of existing clusters, and also why learning networks tend to be self-reinforcing. However, it tells us little about how to initiate and develop, eventually with policy, these learning networks for

development. A different tradition in economic analysis, with its roots in **Veblen (1899)**, looks at the dynamics of institutional change. Veblen uses the metaphor, borrowed from biology, of evolutionary selection to explain the dynamics of successful institutional adaptation to new conditions. This evolutionary perspective was also used by Nelson and Winter (1982) to explain the dynamics of learning at the firm level. North (1990) shows how the development of the right type of institutions is a key factor for the successful development, describing institutional dynamics as a dialectic tension between the existing organizations that strive in the status quo, and the entrepreneurs constantly looking for opportunities as markets and technologies change.

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