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Knowledge for Inclusive Development: The Challenge of Globally Integrated Learning and Implications for Science and Technology Policy

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ABSTRACT

As the importance of knowledge creation and diffusion is increasingly recognized as a major driver of economic growth, questions are starting to emerge on how to establish the conditions that foster the process of knowledge sharing across countries at different levels of development. Under the broad designation of "knowledge for inclusive development," these questions defined one of the strongest themes of the second International Conference on Technology Policy and Innovation (ICTPI), which was held in Lisbon, in August of 1998. While the idea of inclusive development entails a process of shared prosperity across the globe following *local* specific conditions, it is crucial to understand both the features of knowledge-induced growth in rich countries, as well as the challenges and opportunities for late-industrialized and less-developed countries. Thus, this special issue includes a set of extended contributions to the Lisbon conference that are largely grounded on empirical experiences of both developed and developing countries. The aim of this introductory paper is to set the stage for these contributions, with an original contribution on possible roles for science and technology policy in promoting inclusive development. © 2001 Elsevier Science Inc.

Introduction

Here is a virtually unanimously accepted statement: innovations, and especially technological innovations, have been the major drivers of the unprecedented improvement in the living standards of developed countries since the Industrial Revolution.

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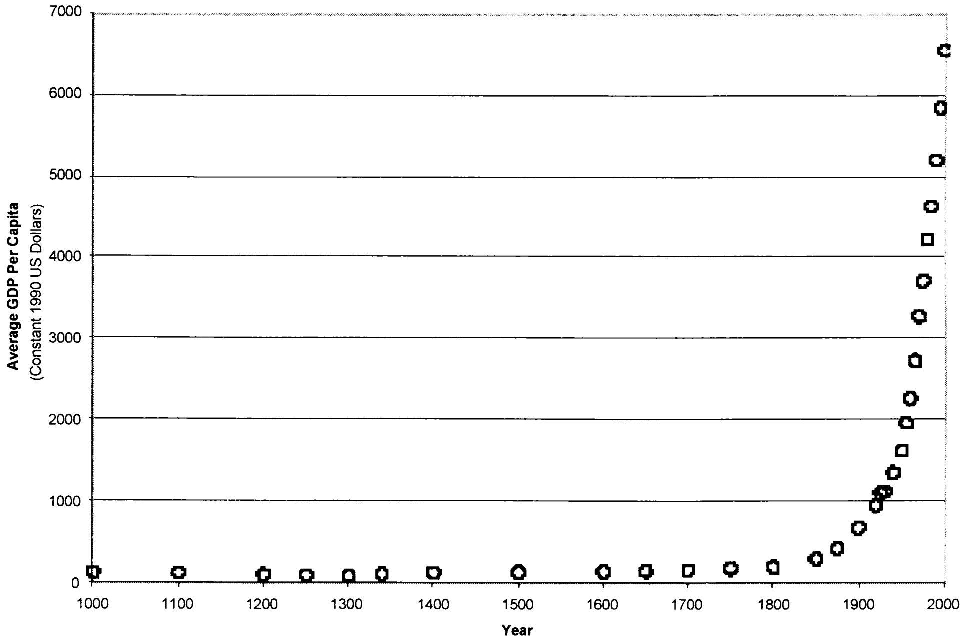

Fig. 1. Worldwide average GDP per capita. Source: de Long [3].

Kuznets [1] named "modern economic growth" the economic progress of developed countries from the outset of the Industrial Revolution. According to Landes [2], it is only after the Industrial Revolution that technology systematically impacts on economic growth. Technological change drives industrial development, and thus having "industrialization" is a required condition for a country's growth to be driven by technology. In Kuznets' own words: "we may say that certainly since the second half of the nineteenth century, the major source of economic growth in the developed countries has been science-based technology—in the electrical, internal combustion, electronic, nuclear, and biological fields, among others," [1]. Figure 1 shows how economic growth worldwide exploded in the second half of the 19th century.

Thus, when one takes a long-term view on the development of industrialized countries, there seems to be a perfect complementarity between technology and economic returns to capital investments and labor, expressed, in the latter case, in terms of wages. In other words, technological change drove increases in per capita GDP and in average wages over time. Samuelson [4] writes: "with the advance of technology and the piling up of a larger stock of capital goods, it would take a veritable miracle of the devil to keep real wages of men from being ever higher with each passing decade. Who fails to see this fails to understand the fundamentals of economic history as it actually happened." The neoclassical model of growth, developed largely by Solow [5, 6], formalizes this idea, proposing a conceptualization of growth based on two factors of production, capital and labor, and an exogenous flow of new technology, which works as the tide that raises the incomes of all.

Even slicing-up aggregate labor into different categories according to various levels education, as the theorists of human capital suggested [7, 8], does not change the fundamental complementarity between people and technology embedded in the neoclas-

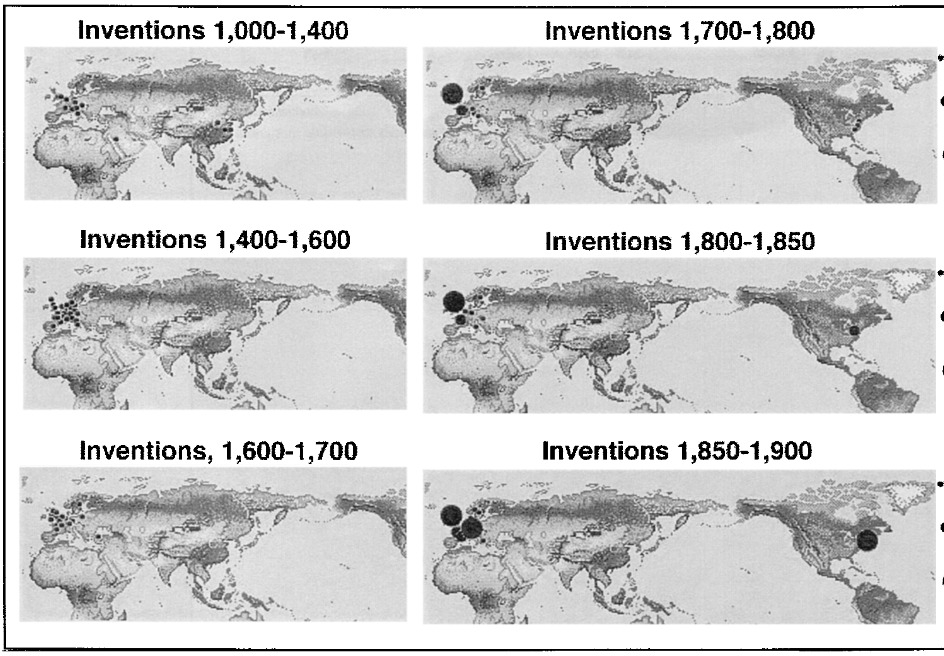

Fig. 2. Origin of inventions in the second millenium (illustrative). Source: Smithsonian Visual Timeline of Inventions [10].

sical model of growth. Human capital (educated labor) is "entered" in the production function framework as just a different type of capital, maintaining its character as a complement to technology, perfectly substitutable with labor. In these models there is no mechanism through which technology can affect differently the wages of workers with different qualifications.[1]

However, we must ask the question: *has this process of economic growth really occurred throughout the world? Have the incomes of every person, in any country, risen according to the neoclassical conceptualization of growth*? Any casual observation suggests that this is not the case. Solow [9], for example, states that models where technology is the ultimate driver of growth are suited "perhaps to Brazil of Taiwan or Portugal [but] I do not imagine they could be [applicable to] Guyana or Zimbabwe or Bangladesh." In fact, most of the benefits of the Industrial Revolution have remained largely in the countries where it was originated and those in their orbit.

Figure 2 illustrates the asymmetric worldwide distribution of knowledge-generating regions. From the 10th to the 14th center a small number of innovations were generated across Europe and China. From the 1400s until the 1700s, Europe was virtually the sole generator of innovations. But the explosion in the number of inventions in the 18th century was even more concentrated in a few European regions, first, and then also in the United States.

The timing of the explosive increase in the number of inventions correlates well with the explosion in the worldwide level of average income. But this explosion in

[1] Although different average wage levels can be attributed to labor and human capital, there is no embedded mechanism to explain different dynamics in each of these wage rates.

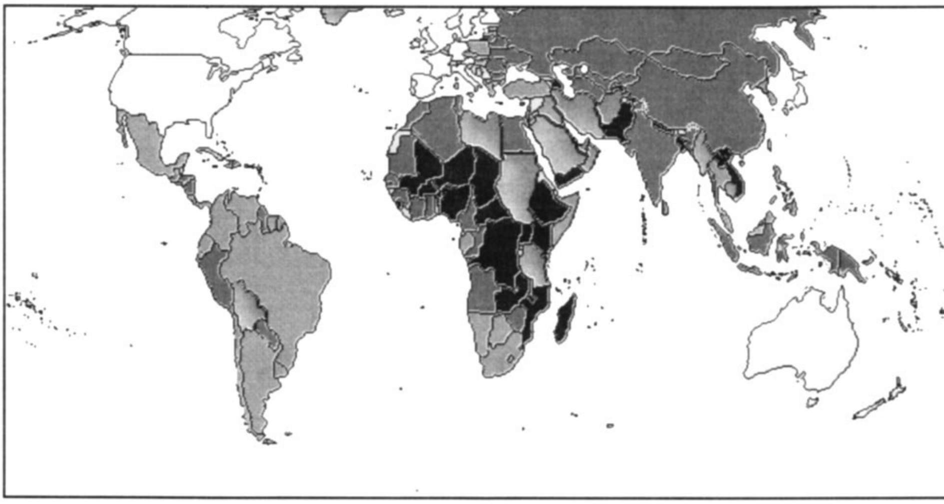

Fig. 3. Rich and developing countries. Legend: Blurred countries—no data; intervals of income are: >10k USD (white); >5k and <10k, light gray; >1.5k and <5K, dark gray; <1.5k, black. Source: World Bank [11].

knowledge creation was concentrated in a few regions, and led to similarly concentrated distribution of income. Figure 3 shows a map of the world where countries are differentiated according to their level of GDP per capita. The lighter the color, the higher the income. White represents the richest countries, with per capita incomes over 10 thousand U.S. dollars in 1997. It is clear that Europe, and North America, which were the originators of the innovations, are the richest countries.

Another illustration of the inequality in the distribution of world GDP is given in Figure 4, which plots the Lorenz curve for 116 countries. To construct the Lorenz curve, countries are first ranked according to their level of GDP per capita, from the poorest to the richest. The horizontal axis represents the cumulative share of population, starting from the poorest to the richest countries, and the vertical axis presents the corresponding cumulative share of GDP. The thick line represents the line of perfect equality. This line shows a world where 10% of the population would have 10% of the income, 20% of the population, 20% of the income, and so forth. The thin line, the Lorenz curve, shows the actual distribution of income: the poorest 20% of the population have only about 7% of the world's income, the 50% poorest only 15%, and the 80% poorest only 35%!

Actually, the real income inequalities are much wider than those suggested by Figure 4, because we are taking countries as the unit of analysis, and thus are ignoring the within country inequality. Still, Figure 4 illustrates that the dramatic increase in the world's GDP shown in Figure 1 has not been shared across countries. Many nations have been excluded from the windfall of riches that has benefitted most developed countries.

We have been stressing the across-country inequality story, but there is another parallel development that merits discussion. And this is the broad dissemination of improvements in well being *within* developed countries. Let us suppose, for a minute, that the process of development since the industrial revolution had been different *within* developed countries. Let us imagine that the benefits of innovation had not spilled over within these knowledge-creating nations into the economy as a whole, but had remained

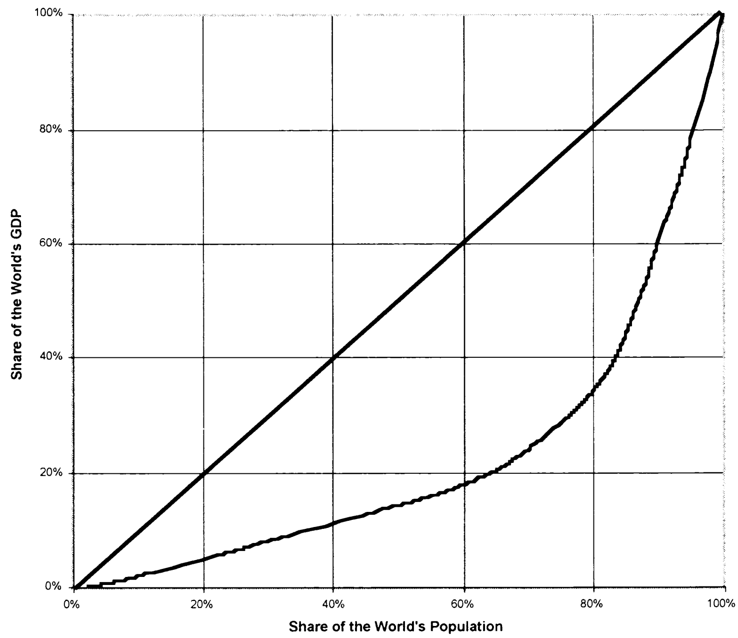

Fig. 4. Lorenz curve for 116 countries GDP in 1990. Straight line, line of perfect equality; curved line, Lorenz curve for the world's GDP. Source: authors' calculations based on the Penn World Tables Mark 5.6, described in Heston and Summers [12].

linked to those individuals that had introduced the innovations. In other words, let us imagine a world where there were no innovation externalities and no innovation spill-overs, and where individual innovators could appropriate entirely and perfectly the benefits of introducing technological change. *Would it be acceptable that a few individual innovators would have riches beyond imagination, while the bulk of the population persisted in medieval poverty*? As Baumol [13] argues, this was not likely to be accepted from an overall "common good" perspective, and not even from the point of view of the innovators themselves. In fact, even if they were very well off, the innovators were likely to want to be surrounded by healthy, educated, and content people, to avoid diseases, increase productivity, and have a peaceful environment.

However, if we take as unit of analysis countries instead of individuals, our imagined scenario is not very far from reality, as we saw. Across the world, but especially in Africa, the Caribbean, and Southeast Asia, many countries have levels of income per capita that are still preindustrial. According to Gallup and Sachs [14], the average income per capita in Africa in 1992 is at the same level of the estimated GDP per capita for Western Europe in 1820. Constant ethnic and political conflicts threaten internal and foreign regional security [15].

It is unquestionable that technological progress has driven the overall improvements in the standards of living across the globe. But is also clear that many countries and many people have been excluded from the benefits of new technology and innovations. Beyond technology, it is "knowledge" (ideas and skilled and educated people) that are increasingly important for economic development. In developed countries the incentives exist to reward and to stimulate the generation of new ideas and to promote the investments in education and training. But we must question whether they are in place in developing countries. According to United Nations [15], 1.3 billion people in developing countries live on less than $1 a day, 32% of the population in transition economies on less than $4 a day, and 11% in industrial countries on less than $14.4 a day. If the developing countries, on average, have much less income than developed countries, one cannot overlook the fact that even within developed countries many people have been excluded from the process of development. Duncan [16] provides a description of the deep and persistent poverty that plagues many communities in the United States, especially in the Appalachian and in the Mississippi delta.

In fact, the situation is much worse than a mere asymmetry in the distribution of material assets, and thus, is largely underestimated when measured only in terms of differences in income per capita. As Robert Fogel [17] stressed in his Presidential Address to the American Economics Association early in 1999, the most daunting problem is that of "spiritual inequality." In fact, Fogel argues that making progress towards inequality in material terms does not entail that spiritual inequality is achieved. And he stresses that, even in developed countries, where material equality is higher than in developing countries, huge chasms exist in terms of such spiritual assets as self-esteem, discipline, work ethic, sense of achievement. The situation is certainly worse in developing countries, where access to education, health, family, and state support and more problematic, but developed countries are not immune. Sen [18] notes that "a great many people in the United States have little access to primary health care which makes a substantial section of its population seriously deprived; and the very high level of regular unemployment, and the social disruption it generates, blights the lives of millions in Europe."

This discussion frames the issue of the need to promote "inclusive development," that is, of the need for a process of development that includes every citizen in any country, as a problem that goes beyond the creation of conditions to generate knowledge. Incentives to create knowledge have existed, in fact, and though in need to be perfected and deepened, have worked rather well for the most part. The most important problem concerns the sharing and diffusion of knowledge. The mere fact that in the economics literature this "diffusion" process has largely been explained in terms of externalities and spillovers, shows that the sharing process is largely an unintended consequence and, in fact, a disincentive for private agents to invest in knowledge creation. Thus, the logic of government intervention, namely in terms of science and technology policies that tackle these market deficiencies, has been to provide incentives to enhance knowledge generation.

In our opinion, if the issue of inclusive development is indeed to be acknowledged as important, efforts should be channeled towards the understanding of the conditions for globally integrated learning processes. Learning, in this context, reflects the idea of sustainable knowledge creation and diffusion, and we contend that the challenge is to make this a feature not exclusive to a few countries, but instead, of the entire global economy. This special issue intends to be a contribution to the effort of studying the conditions for inclusive development through globally integrated learning processes.

The remainder of the paper attempts to progress in the framing of the problems associated with globally integrated learning processes from the perspective of science and technology policies, and to present the contributed papers to this special issue. Section 2 clarifies the association between *learning* and *economic prosperity*, mostly from a conceptual point of view. Section 3 discusses issues associated with the collection of empirical evidence to better assess, understand, and monitor the intangible aspects associated with *learning*. Section 4 proposes some specific challenges to *science and* *technology policy*, mostly in the form of research agenda or research questions for future development. The final section introduces the papers that are part of this special issue.

Learning and Development

The relationship between knowledge and economic development is increasingly the focus of research and policies aimed at ameliorating the living standards around the world [19]. These relationships include the processes through which the creation, distribution, and use of knowledge contribute to economic growth. Much of this new perspective is being driven by the perception that the growth in the stock of knowledge is unprecedented. The key point here is not only that there is *fast* technological change, but that there seems to be an *accelerating* rate of technological progress. Fogel [17] chooses to contrast the development of the plow, around 4000 B.C., with the development of flight, a constant ambition of the human spirit. It took 2000 years to diffuse the plow across the Mediterranean shores, with little improvement, but only 66 years to go from the first airplane flight in 1903 to the point where a man would walk on the moon.

Additionally, this new and unprecedented quantities of knowledge are generally more easily available, and are disseminated faster and more broadly than ever before. Enhanced by rapid advances in information and communication technologies, there have been dramatic declines in the costs of producing, diffusing, and processing information. These advances are transforming the organization of social and economic activity worldwide, leading to the emergence of the so-called network economy (see Varian and Shapiro [20], for a treatment based on economics analysis, and Kelly [21] for a more visionary perspective).

Thus, development can be regarded as being dependent on knowledge accumulation through "learning" processes. Conceptually, the foundations for the relationship between learning and economic growth have been addressed in the recent literature [22]. Learning is reflected in improved skills in people and in the generation, diffusion, and usage of new ideas [23]. The ability of a country or region to continuously generate skills and ideas (which is to say, to accumulate knowledge through learning) is the ultimate driver of the long-run economic prospects of any region [19].

However, literal readings of the neoclassical literature privileged the accumulation of physical capital in the form of machinery and "industrial capacity," and this perspective still informs much of the current policies [24]. Beyond the accumulation of new machinery, more intangible aspects associated with new technologies have been as important drivers of growth. And of equal, if not more, importance than technology to promote economic welfare, were institutional innovations, especially those that protected and encouraged entrepreneurship [2, 25]. Further innovations associated with the institutionalization of science and education activities led to the emergence of the modern of the modern research and educational infrastructure. In fact, Landes [26] argues that while Britain was the originator of the industrial revolution, with learning-by-doing as the main driver, Germany, by institutionalizing scientific and educational activities, was eventually able to surpass Britain.

In this section we review and integrate a series of contributions to scholarship from different academic areas, trying to clarify between learning and development. First, we show that learning at the aggregate level of a region or nation needs to be regarded in the context of the social interactions and institutions that govern the behavior of individuals and organizations. Thus, we establish a relationship between learning and the idea of social capital. Secondly, we discuss how the concept of social capital has increasingly been brought into studies that aim to explain and provide policies to enhance growth and development. This will also be used as a review of some of the empirical evidence that shows the importance of social capital. Finally, we propose an operational definition of social capital the emphasizes networks and institutions, from which we intend to draw some policy implications in section 4.

LEARNING AND SOCIAL CAPITAL

The ability to learn seems to be the main driver of long-term growth, but learning can occur at different levels. Individual people, firms and organizations and countries all are depending of learning for development. Lamoreaux, Raff, and Temin [27] write: "more than any other factor, the ability to collect and use information effectively determines whether firms, industry groups, and even nations will succeed or fail." There are also different ways through which people, firms, and countries can learn. Learning can be an unintended consequence of experience and augmentation of scale, as formalized at the firm and then country level by Arros [28]. Formalized and purposeful learning methods include education and training and research and development. The new growth theories attempt to formalize the way in which these and other learning mechanisms can impact on economic growth [29].

Development results from a combination of all these 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. In fact, as some have argued, inequality can even be considered positive, because it provides incentives to get ahead and a context where there are many aspirations to achieve [30]. 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.

Here we will focus primarily on learning at the country or regional level, and to a lesser extent at the organizational level. Learning at the individual level is outside the scope of this paper, and is in itself the subject of several academic and scientific disciplines. Despite the analogies between how people and firms and nations learn, management policy have a discretion and a potential impact to change the way in which organizations and countries learn that is not always available to people individually.

When focusing on regional and national learning, the first question to address is *who are the actors* 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 and 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 they key to regional learning goes beyond the mere aggregation of this individual capacity for knowledge accumulation. It entails *collective learning*, as suggested by Wright [31] in the context of the United States, which means more than just individual learning, or learning within the boundaries of an organization. Regional learning also incorporates not only an individual isolated inventor, an Edison or a Graham Bell, not even a single very creative company, such as a IBM or 3M, but the idea of *collective invention*, as first proposed by Allen [32]. Instead of individual or even aggregated human capital, the key for regional learning seems to be the capacity to build on *social capital*.

The concept of social capital is not well defined, because different authors emphasize distinct features. In the broadest sense, social capital is associated with the "social capabilities" [27] that allow a country or region to move forward in the process of development. In a more sophisticated treatment, Coleman [33] states that social capital is "a variety of different entities, with two elements in common: they all consist of some aspect of social infrastructure, and they facilitate certain actions of actors—whether personal or corporate actors—within the structure."

The usage of the term "social" entails that we are moving beyond a mere "economic" analysis, where "economic" is 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 at a set of social capabilities that allow it to function according to the theoretical principles of allocative efficiency and Pareto optimum social welfare. We next turn to an analysis of studies that look into the process of economic development within this broader perspective.

SOCIAL CAPITAL AND DEVELOPMENT

The relationship of social capital for the economic performance of nations was recognized by Olson [34] and North [35], in broad descriptions of the process of development. 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 endeavored in efforts of privatization and promotion of competition. But as has become increasingly clear, that underlying social conditions and institutions for these new markets to function properly just were not there. Stiglitz [36] reviews the 10 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 transitions are today worse off (in terms of GDP) than they were 10 years ago. Georgia lost almost 70% of its GDP, the Russian Federation almost 50%, and the Slovak Republic, a relatively good performer in this dire context, about 5%. 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.

But Stiglitz [36] notes that legislation and even enforcement alone are not enough: "the social and organizational capital needed for the transition cannot be legislated, decreed, or in some other way imposed from above. People need to take an active and constructive role in their self-transformation; to a large extent, they need to be in the driver's seat. Otherwise, the reform regime is only using bribes and threats to induce outward changes in behavior insofar as behavior can be monitored—but that is not the transformation." Cast in this light, the problem of development, and the meaning of learning, goes much beyond the accumulation of capital and the access to technology of neoclassical, and even endogenous, growth models, 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. This is an important issue in itself, but has been studied intensely also because of the need to find policies to help the transition of the former Eastern Bloc countries and, more generally, to enhance the growth of developing countries throughout the world. 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 [37], who showed that capital accumulation could account for most of the economic growth of the high-performance Asian countries. Krugman [38] extended the argument, arguing that these countries were repeating the experience of the Soviet Union in the 1950s, and that no long-term growth would be sustainable, because 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. As Bruton [22] wrote: "There is increasing doubt that growth is as simple as it appears in [these] arguments, and renewed emphasis is being placed on more basic characteristics of an economy, especially entrepreneurship, institutions, and knowledge accumulation and application." Rodrik [39] 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 importance of social capital has also been noted in the context of late industrializing countries and, for example, Henderson and Morgan [40] relates it as part of the "institutional" turn in regional development studies, with emphasis to less favored zones in Europe. Following Cookes and Morgan [41], these authors claim that *networks* have the potential to make both states and markets more effective, namely through "intermediary institutions," such as interfirm networks, trade associations, chambers of commerce, civic associations, regional development agencies, and labor unions. These self-organized institutions have the potential to play a significant role in fostering learning, innovation, and development among their respective members and within their regions. However, two key questions arise: first, *how* these *learning networks* emerge, namely if they can built through administrative and top-down processes; second, *which type* of networks do emerge along the development process and how far they are able to promote endogenous learning. In this respect, Amin [42] and Morgan and Nauwelaers [43] call our attention for the predominantly *vertical* and *asymmetric* character of *networks* in European less favored zones (including zones such as Portugal, Greece and the south of Italy), which render local institutions highly dependent upon state or corporate hierarchies. This is to be contrasted with the more dynamic, *horizontal networks*, which tend to form around agents of broadly equivalent status and power.

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 [44] 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. What do Freeman and Lindauer offer as an alternative? Lack of political stability, failure to secure property rights, corruption, and the dictatorship. Thus, Freeman and Lindauer 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.

Hall and Jones [45] show evidence that incorporates and confirms this discussion on the importance of social capital for development. Addressing the explanations for differences in output per worker across 127 countries, these authors separate what they call "proximate explanations" (human and physical capital) from the deeper determinants of economic growth. To highlight this distinction, they first show that output per worker in the five countries with the highest levels of output per worker in 1988 was 31.7 times higher than output per worker in the five lowest countries (a geometric average was used). Differences in human capital and in physical capital intensity (capital divided by output) accounted for, respectively, 2.2 and 1.8 (as product factors). Thus, a product factor of 8.3 was due to differences in productivity. Without the differences in productivity, the difference between the richest and poorest countries would be only a factor of 4 (1.8×2.2).

Hall and Jones [45] proceed with an exploration for the causes for the differences in productivity. They find that these differences can be explained by what they call "social infrastructure": the institutions and government policies that provide the incentives for individuals and firms in the economy. This is the first work on the empirics of economic growth that directly shows the relevance of social capital for development.

TOWARDS AN OPERATIONAL CONCEPTUALIZATION OF SOCIAL CAPITAL

All the examples cited above highlight the importance of social capital for development. A common feature of the studies discussed previously is that they all recognize the importance of physical and human capital and technology, but assert that the process of economic growth depends also, even crucially, from the way in which the economic actors interact and organize themselves. Grootaert [46] has suggested that social capital is the missing link in the explanation of how human and physical capital and technology interact to produce economic development. 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 [47] 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 arguing that it had a 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, because 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 Italy's North 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, which presents a grim prospect for policy. If a country of region has not had the luck to have benefitted from a historical event or context that has led to the conditions for the creation of social capital, there is not much that can be done today. Thus, regions "endowed" with social capital, as they may be endowed with natural resources such as oil of a fertile land, will do well. Those that do not have this endowment will suffer. And they will have to "learn," through trial and error, how to create their own level of social capital over time.

However, recent studies have suggested a more optimistic view, one where policy can indeed influence the development of social capital. Cohen and Fields [48] analyze the explosion of Silicon Valley (SV) in the second half of the century in the light of the accumulation of social capital, but one of their most important points is that the SV social capital is *different* from Putman's northern Italy variety. People do not know each other in SV, and they do not interact socially as in Northern Italy. As these authors put it, SV 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 United States. Rampant individualism, rather than generous sense of community, characterizes SV.

But, nonetheless, SV 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 U.S. policy, 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 SV, rather than trust and informal sentiments of respect and sense of community, is largely aided by legally binding formal contracts. Lawyers and accountants are abundant in SV, and have also resorted to taking also stock options instead of traditional payment for services.

The discussion of these studies indicates that probably there is not a single type of social capital. Table 1 summarizes the differences in social capital in North Italy and in SV. Despite the differences, it is worthwhile to note the common structural aspects that are key to having social capital. Because social capital depends on connections and relationships between people and organizations, the concept of *network* emerges as fundamental.

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

TABLE 1
What Type of Social Capital?

	Generic description	Type of networks	Type of relationship
North Italy Putman [47]	Dense civil society leading to a rich social community	Networks of civic engagement	Informal, familiar and communal trust
Silicon Valley Cohen and Fields [48]	Collaborative partnerships for innovation and competitiveness	Networks of innovation	Legally binding formal contracts

Italy, or largely formalized, such as in SV.[2] 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 an earlier section when we discussed the transition problems of the formerly socialist countries. Stiglitz [36] 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 the 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 [35], 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*.

To summarize the discussion so far, we have established that the 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 [49] analysis is cited as the first analytical treatment of the consequences of localized networks externalities for development. The 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 exertnal 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 [31] defends that this type of regional learning occurred also at the national level in the United States in the aftermath of the Industrial Revolution

[2] This does not mean, however, that now informal networks exist in SV, much less that the informal networks that do exist are not important. Still, the foundations of business relationships in SV are much more strongly based on formal contracts than in Northern Italy.

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 [50], 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 [51] to explain the dynamics of learning at the firm level. North [35] 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.

None of the case studies and theories analyzed will provide single and definitive answers to the problem of achieving inclusive development. But it was our aim in this section to frame the problem of development in the context of the necessity to create and sustain conditions for regional and national learning. We established that social capital was key, and that networks and institutions are the elements out of which social capital is born. Different types of networks and institutions can be effective as long as they enable collective learning and collective innovation. As in every situation where networks are important, history matters. *Path dependence* and *increasing returns* lead to self-reinforcing cycles, whereby events, often sporadic and serendipitous, define current patterns of development. But the good news is that if we understand the dynamics of institutional change and evolution, we can also create conditions for future development. What these actions may be will be the subject of another section. In the next section, we try to address the crucial issue on how to measure knowledge and learning performance.

Metrics for Knowledge

The availability of specific data showing the growing importance of knowledge is still scarce. The empirical advances have not accompanied the important theoretical advances in a better understanding of knowledge-based growth, much less the reality of the on-going processes of learning-based development. This is also due to the characteristics of knowledge, which is extremely difficult to measure quantitatively. Howitt [52] provides an excellent overview of the difficulties with the measurement of knowledge in the context of growth models. Knowledge is certainly not the only area where economics has measurement problems. Thus, Fogel [17] claims that economics needs to catch up with the economy, in the sense that much is happening that is unaccounted for and not understood at all. Specifically, in terms of measurement, Fogel [17] points that "the root of the problem is the difficulty in measuring output in the service sector which now represents two-thirds of the economy"; moreover, the continuous proliferation of new services, and the processes of commodization, industrialization and reorganization of services on a global scale, suggest that services are at the core of current structural changes in modern economies.

Technology and innovation activities represent major forces behind such structural processes, with information and communication technologies playing a pivotal role in revolutionizing the ways most of "traditional" services are produced, traded, and deliv-

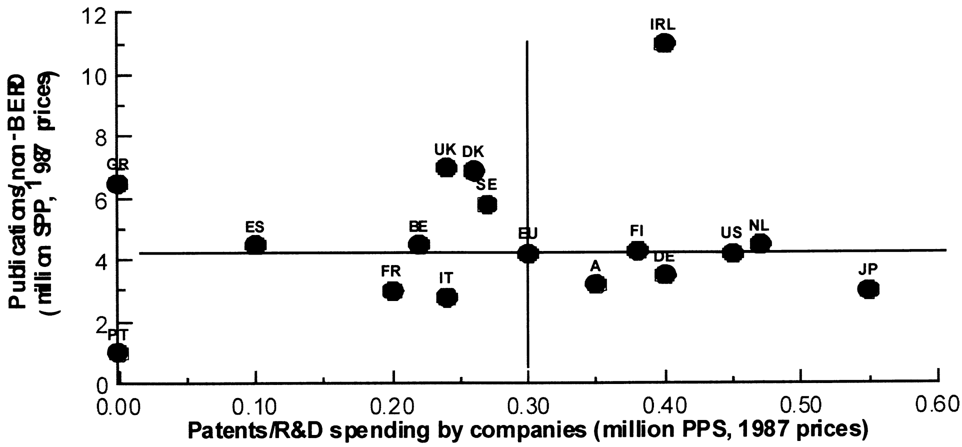

Fig. 5. Measures of scientific and technological capacity in OECD countries for 1996, as measured by the ratio between the number of publications and the R&D spending by public organizations (vertical axis) and the ratio between the total number of patents and the business R&D spending (horizontal axis). Source: Caracostas and Muldur [56].

ered, as well as offering opportunities for the generation of new ones in a variety of service industries. This already suggests that the old view according to which service industries are technologically backward would be misleading. An increasing amount of empirical evidence is showing that this is the case.

Until recently, the bulk of investment in scientific research and experimental development of the business sector has been carried out by manufacturing firms, but the picture may be changing. Recent estimates [53] show that service industries now perform in most industrialized countries almost a fourth of total business R&D (25% in 1991 compared to a share of 4% in 1981). Also with respect to the adoption and diffusion of new technologies, the service sector does not seem to be backward relatively to manufacturing. Service industries are heavy users of information technologies, and the bulk of information technology investment is actually used by services—around 80% in the United Kingdom and United States.

One problem with defining the stock of knowledge is that access to knowledge is limited and, therefore, steps should be taken to increase its diffusion across people, institutions, and countries. Another problem consists in separating economically useful from irrelevant knowledge, even though this distinction is extremely difficult to be done in practice: some piece of information may sit in the shelves for a long time until it becomes crucial for solving a problem, while some knowledge at the basis of a technological paradigm may suddenly become obsolete.

Economists use to solve the problem of measuring knowledge by looking at indicators that reflect the rate of return on intellectual assets and use them to calculate the present value of intellectual capital, i.e., human capital. Such calculations imply a number of simplifying assumptions, including the definition of the depreciation rate. A more general methodological approach is the focus on processes and flows rather than on states and stocks. This is basically the choice made in the calculation of science and technology indicators.

At present, various indicators are used to illustrate the structure and the changes of the science and technology system and its impact on the economy and society, and Figure 5 shows a typical example established with publications and public R&D

expenditure, versus patents and business expenditure in R&D. Alternative analyses have considered innovation surveys, the technological balance of payments, trade of high-tech products, intangible investment, surveys on production technologies, the analysis of innovations, human resources, bibliometrics, the diffusion of information and communication technologies [54].

Besides all the questions associated with the type of indicators used in Figure 5, this data has been critically important to design science, technology, and innovation policies worldwide. For example, the measurement of the differences between the private and social returns of *private investment* in R&D has been pursued by several scholars. Analysis, such as that described by Conceição et al. [55], resulting largely from spillovers to the entire society of private R&D efforts, or, in other words, positive externalities, has established the conviction that there is a systematic *market failure* justifying the *intervention of the government*. However, if any information can really be taken from the broad spectrum of values given in Figure 5 or OECD countries, is that the design of science and technology policies must encompass the careful analysis of the specific conditions following the trajectory of each country. This requires an increased *accountability* and *observatory effort*, which has clearly not been equally considered by every country, even those in OECD.

Besides the need to improve and systematize the collection and use of conventional science and technology indicators, the analysis of intangible investment and innovation surveys shows that knowledge is deeply socially embedded in institutions and in the socio-economic environment in which they operate. The knowledge content of products and production processes is becoming more and more important, and investment is rapidly evolving towards the acquisition of services and the carrying out of activities that pay off over a long period of time. Intangible investments includes a series of items beyond R&D, such as: training of personnel, software, marketing, as well as good will, mineral exploration, development of organizations, rights to use intellectual property, or concessions.

Taking the experience of Finland and The Netherlands, four components—research and development, education and training, software, and marketing—make up about 80% of the total intangible investment which, in turn, represents between 20 and 50% of tangible investment. In Austria it has been calculated that intangible investment is 43% of all business investment.

Innovation surveys conducted in some 30 countries tell a similar story: half of the innovation expenditure of manufacturing firms is linked to the generation and acquisition of new knowledge through design, R&D, trial production, acquisition of know-how, training, and marketing, the other half being spent for new machinery and equipment. Looking at the activities that are most often carried out for introducing new products and processes in service firms, the most frequent ones are R&D, development or acquisition of software, investment in machinery, and training of personnel. The data from innovation surveys show also that innovation in firms is a quite diffused phenomenon, with about one-third of the firms introducing innovations over a 3-year period [53].

The metrics for knowledge has to face at least three challenges. First, a *comprehensive view* encompassing many areas such as science, technology, knowledge, economic growth, employment, the environment, firm and social organization, and education, institutions is more and more required. While no single model can as yet cover such a vast territory, certainly a new crossdisciplinary understanding can create a new way of looking at indicators and innovation systems. Second, we have learned that national and local *institutions* and *institutional cultures* do matter and, therefore, indicators of these "intangible" aspects need to be devised. Third, we need to be able to capture the *dimensions of knowledge* (tacit and codified) as well as how the diffusion process takes place in competitive environments (markets) and in noncompetitive settings (education, the health sector in countries where it is mostly public).

Challenges for Science and Technology Policy

Looking at the world's distribution of income and technology across countries today, as represented in Figure 3, can lead to a sentiment of inevitability. *But was it really inevitable or three centuries ago that the United States would become the richest and most powerful country in the world as it is today*? If we look at Figure 2, it is clear that the United States' ability to generate knowledge only emerged with any significance almost one century after the industrial revolution, which was born in Europe. Thus, as Gavin Wright [31] points out, for U.S. development "what mattered most was the emergence in the nineteenth century of an indigenous American technological community, pursuing a learning trajectory to adapt European technologies to the American setting." The challenge before us, if we want to achieve a stage of *inclusive development*, is to globally promote similar "learning trajectories." Beyond every single country, where local/regional based learning networks emerge, it is important to extend these learning networks and trajectories beyond a single country, so that they reach the entire Humanity.

Clearly, these issues are too broad to be addressed in a context where we are looking for specific policy suggestions. In the broadest sense, any discussion of these issues must include a treatment of the need for the promotion of democracy, peace, and the rule of law. These are the preconditions that we so strongly emphasized earlier as being essential in the case of the poorest countries. However, we will constrain ourselves to suggestions for questions to be addressed in the context of science and technology policy.

THE REQUIREMENTS FOR SCIENCE AND TECHNOLOGY POLICY

Why the Focus on Science and Technology Policy?

As we emphasized earlier, learning can occur in many shapes and forms, some of which are informal, and other formal. The institutions and organizations that comprise the national and regional systems of science and technology largely attempt to formalize and accelerating the learning process for individuals, firms, and nations. Thus, by looking at this particular set of organizations and their networks and institutions, we could be able to suggest routes for policy that can positively influence the conditions for inclusive development through learning.

The challenges for policy to move towards inclusive development are really twofold. First, *what can be done* at the regional and national level *to start and sustain learning networks and trajectories* that can lead to development? Second, *how can the overall global learning processes be made more inclusive*, so that fewer countries are excluded, extending the reach of the learning networks globally?

At the national level, it is increasingly clear that innovation is not a direct consequence of R&D. In the academic literature, the lack of validity of the linear model of innovation has been repeated *ad nausea*, but the fact remains that it still informs much of the policy rationale for investing in R&D. There is no question that the ideas that result from formalized knowledge exploration activities lead, in the long-run, to innovations, but to expect this to be so in the short run is misguided both for firms and governments. Kortum and Lerner [57], for example, show that venture capital is probably much more effective in promoting innovation that R&D at the firm level.

This does not mean that firms and governments should stop doing R&D, but rather that they should do it for the right reasons. And there are many, from promoting human capital, to extending the frontier of knowledge. But in terms of public policy, the realization that innovation and R&D are not as connected as once thought is particularly important. This realization means the firms may lack even more incentives to perform their own R&D as previously thought, and thus require a stronger intervention of the public sector. This may be particularly important for late industrializing countries, with scientific and technological systems not yet fully developed and matured. Often these countries, such as Portugal, show very low levels of private commitments to R&D, with disproportionate high government expenditures in R&D.

With the hindsight gained from the discussion above and that of Conceição et al. [55], we can also "explain" the increased need of public intervention for science and technology policies, as resulting from the *nonrival character of software*. As indicated by Conceição et al. (1998), market mechanisms do not yield the allocation efficiency to be expected from competitive exchange. Expanding on the ideas proposed by Nelson, David, and Dasgupta [58] suggest three ways to yield the conditions for the effective production of nonrival software. The first is *patronage,* consisting on a mechanism by which the government gives direct subsidies to producers of nonrival software, on the condition that it becomes publicly available at virtually zero cost after it has been produced. The competitive research grants awarded by any national Science and Technology Foundation are an example. The second, *procurement*, is based on the direct production of the goods by the government, awarding specific contracts to private agents whenever necessary. The case of State Labs in many countries, illustrates this feature. Finally, the third, *property*, is associated with the privatization of the nonrival software, awarding the producer monopolistic rights that yield returns large enough to cover the total costs of production. Specific legal instruments include patents, copyrights, and trade secrets. Both patronage and procurement rely on a direct intervention of the government, by which the nonrival software remains nonexcluded, and, therefore, effectively a public good. Property grants private producers of new knowledge exclusive property rights in the use of their creations. This yields the private incentives in which markets operate efficiently. In the current political and economic context in which governments are increasingly called to reduce public expenses, the property mechanism may seem a suitable way to foster the development of new software.

It is clear from the analysis above that it is crucial not only to make available financial resources (namely public resources), but to do so *in a way* that provides the right incentives for S&T organizations *to hook up in learning networks* that can generate localized social capital and endogenous growth dynamics. That *way* is definitely *not unique*, and depends on local conditions, roots, and trajectories, which raise the question of *inclusive development.*

At the global level, growing trade liberalization and the increasing reliance of information and communications technologies will certainly contribute to a wider and faster diffusion of knowledge, amplifying the reach of successful learning trajectories. Wolf et al. [59] show how financial flows from the United States into Europe have helped to foster the launching of biotechnology start-ups in Europe. This is a typical example of the broadening of the scope of a learning network that we have been mentioning. Financial resources and management expertise from the United States, coupled with public support for R&D and education in Europe, help to implement creative firms in Europe. Financial returns will go to the United States, but human capital and knowledge will remain in Europe.

A critically overlooked aspect to enhance knowledge flows around the world is associated with the free movement of people. Although possible in large regional contexts, such as the European Union, the United States and Canada, and Mercosul, there are still major barriers to the movement of people, crucial bearers of knowledge.

Whether we are interested in enhancing local and regional learning networks, or globalizing the reach of successful learning networks, it is crucial to understand the local reality, according to different angles. The Comprehensive Development Framework, the World Bank strategy to guide its development policies for the 21st century, clearly identifies the forces of globalization and localization:[3] "*globalization*, reflecting the integration of the world, will require the nation-state to reach out to international partners in order to manage changes affecting trade, financial flows, and the global environment; *localization*, reflecting the assertion of regional identities, will push the nation-state to reach down to regions and cities in order to manage changes affecting domestic politics and patterns of growth." The papers in this special issue precisely attempt to provide some of these more local perspectives in a context of globalization. Mostly from country-level studies, the papers give us a perspective on relevant issues to move towards learning-based inclusive development.

BUILDING ON SPECIFIC CONTEXTS TOWARDS INNOVATION

The analysis above emphasizes the importance of knowledge creation and diffusion as a major driver of economic growth, in a context where social capital is shown to be critical. Here, we attempt to discuss the process of building up a conceptual framework to analyze the conditions that *foster innovation* and the processes of knowledge sharing across countries at *different levels of development* and following *local* specific conditions. Other authors [41, 59, 60] have looked at the specific aspects of the organization of innovative activity in Europe, and Henderson and Morgan [40] call our attention for the need to stimulate localized learning, innovation, and indigenous development *within* less favored regions, LFRs, in Europe.

In these terms, although there is an emerging set of literature on technological innovation and industrial economics looking at the distinctive features and institutional characteristics of specific regions [59, 61], there have been few attempts to build analytical frameworks to improve understanding and to allow the development of well-sustained technology policies for less favored zones and late industrialized regions. In fact, the *neoclassical approaches in industrial economics* have emphasized the analysis of the microeconomic behavior of firms and built theories specialized in the American, and Anglo-Saxon systems and related market dynamics. On the other hand, *evolutionary economics* have attempted to improve our understanding of *learning* processes and the role of institutions in economic development, but have not specialized on the specific historical context of any region, namely those characterized by late industrialization (e.g., Cooke and Morgan, 1998). Building on the evolutionary approaches and in system theory, the concept of "*national system of innovation*" [62–64] has led to numerous studies of individual countries, but there is still a long way to go to assess the specificity of transition economies, late industrialized regions and, above all, developing countries.

In this respect, we list below several aspects aimed to contribute for the development of an analytical framework to help understanding the *dynamics of technological innova-*

[3] Available on the Internet at http://www.worldbank.org/wdr/2000/overview.htm.

tion, considering local contexts and the specific opportunities for the emergence of the information society. The analysis has been built based on several developments in understanding the process of technological change and the relationship between innovation, industrial development and science [55, 59], as follows.

- The importance of the *learning dynamics of firms* and related *routines* have been increasingly considered as key to the processes of knowledge accumulation, innovation and growth [51]. In this respect, "firm competencies" affect the ability of firms to innovate and shape their technology trajectories. Building on these ideas, the *role of institutions* in economic development has been emphasized over years and an important message [65], is that the specificity of knowledge accumulation is a primary determinant of the observed dynamics in both organizational forms and revealed competitive performances.
- Besides the importance of the "evolutionary" approach to technological change described above, a prevailing view [66, 67] has been that of industry amalgamate through a process of *technological convergence*, namely centered in digital technologies. Although there is still no evidence of success in moving towards a fusion of technologies at the corporate level [68, 69], with communication companies retaining their major technological and market strengths in communications, and computer firms in computing, the question of convergence has reemerged in the late 1990s with many more technologies to produce a single product, and many more products produced from a single technology. In this respect, analysis has shown a need for a *balance between specialization and diversification*. Also, the results of von Tunzelman [67] suggest the need for *considering "dynamic capabilities"* as an ongoing process of interaction between the evolution of products, technologies, and processes. In addition, the analysis suggests the restricted extent to which "market forces" are reliable to carry out the necessary restructuring at institutional levels.
- *Innovation* has been considered as the driving force of *industrial dynamics*, affecting firm's starting-up, development, and growth, as well as their diversification and changes in market structure. At the same time, the process of *technological change*, as the result of knowledge accumulation, has been closely connected with the innovative behavior of firms.
- Building on the concepts mentioned above of technological convergence (namely of communication and information technologies) and the close relationship of innovation and industrial dynamics, the opportunities for *e-commerce*, the emergence of a "new economy" [21], the related market for *internet services* [70], call for the need of a renewed framework for the analysis of technological innovation, namely in terms of firm competencies and the "dynamic capabilities" mentioned above.
- The *spatial patterns of innovation* and the related geographical dimension of economic and social development have witnessed a renewed and increasing interest in the literature [41, 71], but attention is to be focused on the ability to build; I "social capital," as described earlier in this paper. This focus on relational assets is part of the "institutional turn" in regional development studies, as a result of the relative failure of classical approaches, which sought to privilege either "state-led" or "market-driven" processes, regardless of time, space and milieu. The institutional perspective emphasizes a more historical-attuned approach, which is particularly important to discuss technological innovation in

zones characterized by weak science and technology systems, at least on the basis of conventional indicators.

- Besides a common trend of considering geographically localized knowledge externalities and the spatial clustering of innovative activities, analysis has continuously shown the *sectoral-specificity of industrial and technological change*. In fact, the so-called "technological regimes," defined in terms of the knowledge base and of opportunity, appropriability, and cumulativeness conditions, are major determinants of differences in the patterns of innovation across industries [72]. This has led Antonelli [73, 74] to extend the well-known Pavitt's taxonomy of industries (including science based, supplier-dominated, specialized suppliers, and scale-intensive industries) with a new category of "skill-intensive" industries, to improve understanding of the dynamics of technological change in European traditional industries [75].
- Particular attention has been devoted in last years to help understanding aspects of innovation related with the process of building the "social capital" mentioned above, including *interactive learning, local externalities, and networks* among institutions [76, 77]. Related evidence on *critical mass and saturation* of successful clusters has been drawn for high technology European clusters, but the analytical framework remains to be shown to be applicable to traditional industries and less favored zones.
- A great deal of effort has been devoted to analyze the contribution of *academic research* to technological change, with particular applications to business firms, and the related questions associated with the importance of *public policies*. Among others, Pavitt [78, 79] has shown that technological knowledge is not just "applied science," but a capacity to solve complex problems, including a strong component of tacit knowledge. The main contributions of academic research vary among research fields and economic sectors, being not through the provisions of immediately applicable ideas, but indirectly through the adoption of skills, techniques, and professional networks.
- In addition to the aspect of the importance of sound academic research for innovation, recent work in the *economics of science and higher education policy* has emphasized the distinctive features of *universities* for the generation and diffusion of knowledge, and more generally for social and economic development [80, 81]. Conceição and Heitor [23] call for the need to preserve the institutional integrity of the university, this requiring the institutional reforming and the clarification of the relationships between universities and the state, as well as between universities and the system of innovation.

The various aspects above include heterogeneous approaches to technological innovation, but consider "change" at the center of the analysis. This has been considered throughout the series of *International Conferences on Technology Policy and Innovation*, but taking into account that firms' competencies are characterized by *stability and inertia* and, therefore, *lock-ins and competence traps* are expected to occur, in that successful firms may be driven by their success in existing technologies to disregard new alternatives. Other important aspect to take into consideration is that the phenomena of *increasing returns and path dependence* affect the nature of the innovation processes.

Among the various aspects raised above, it should also be noted that the *sectoral specificity* in the organization of innovative activities, on one hand, and the *specific characteristics of local systems of innovation*, on the other hand, are expected to play a significant role in shaping the organization of innovative activity. The prevalence of one effect over another depends on history and competitiveness of firms and their degree of internationalization.

Following Antonelli [74], the notion of *localized technological change* is particularly appropriated to understanding the dynamics of innovation in much of the world not characterized by advanced and well-structured Science and Technology systems. The direct implication is that the type of indicators used in Figure 5, such as R&D intensity or patent counting, fail to assess the related innovative capability, because technological change is mainly based upon informal learning processes (e.g., by doing) and tacit knowledge, rather than by conventional R&D activities. In this case, Antonelli and Calderini [82] show that "the internal bottom-up learning process based upon the improvement of design and technological processes plays a major role in feeding the continual introduction of technological and organizational innovations." In this respect, the authors conclude *that technological knowledge is embedded in the specific circumstances in which the firm operate, and its generation is the result of a joint process of production, learning, and communication,* of which R&D activities are only a part. In these terms, current evolutionary economics has shown the importance of path dependence of economic processes, in that it is at the core of selection mechanisms between competitive firms and technologies [83]. Competition is therefore the result of *the rate of change of market share*, apart from being dependent on differences in the rates of growth of individual firms. The result is a fully endogenous process which, in the presence of increasing returns, gives rise to a strong interdependence between *specialization and diversification*. The direct implication for innovation policies is the important but limited role of demand at the firm level in assessing the amount of incentives for firms to introduce technological innovations. In more general terms, the analysis call for the need to feeding all the processes of learning ("formal" and "informal"), implementing technological cooperation among firms and between firms and research institutions, and on the process of on-job-training of the work force. Technological centers specifically designed to sustain localized processes of technological change might play an important role in this context, as analyzed later in this report.

BUILDING A DYNAMIC NATIONAL SCIENCE BASE

Following Pavitt [79], "innovation studies confirm Tocqueville's prediction that continuous technical change in business firms in modern society would require the development in close proximity of publicly funded basic research and associated training." In this context, analysis has shown that the main practical benefits of academic-based research are not "easily transmissible information," but it involves the transmission of tacit and noncodifiable (or not yet codified) knowledge, with tendency for geographically localized benefits [84]. Furthermore, following Hicks [85], countries and firms benefit academically and economically from basic research performed elsewhere only if they belong to the international professional networks that exchange knowledge. This requires high-quality foreign research training and a strong presence in basic research, mainly because *academic research is certainly not a "free good,"* although it has some attributes of a "public good." In this context, Pavitt, among others [86, 87], conclude that "public expenditure on academic research is a necessary investment in a modern country's capacity for technical change."

To conclude, one must consider the nature and extent of the influence of national patterns of technological change on the national science base. The analysis suggests the coevolution of scientific performance with national technology and economy, in that "the rate and direction of the development of a country's science base is strongly influenced by its level of economic development" [79]. Casual observations have, however, shown that patterns of scientific strength and weakness are strongly influenced by the nature of the societal and technological problems to be solved. In any case, current understanding of the complexities of the knowledge bases that underlie future technological knowledge base is very limited, what led Pavitt [79] to conclude that ". . . The aim of policy should be to create a broad and productive science base, closely linked to higher (and particularly post-graduate) education, and looking outward both to applications and to developments in other parts of the world." However, it must be made clear that we believe that it is the lack of understanding of the complexities associated with the knowledge bases mentioned before that strengths the need for foresight studies, which should be appropriately used for policy purposes.

If any conclusion can be taken with direct application to developing and, even, late industrialized countries, is that allocation to resources between broad fields of science should increase, and that inadequacies in the rate of technological change should not negatively influence academic research. However, important questions remain to be solved, mainly in terms of the way academic governance influences the performance of basic research activities, and the linkages between basic and applied disciplines. Also, the way the demands for knowledge influence research policies remain to be examined.

This must clearly be considered together with the specific nature of the process of *localized technological change* mentioned before, which is based on a mix of generic (and, therefore, codifiable) and tacit knowledge, with the latter acquired by means of lengthy processes of learning by doing [73]. As a consequence, the questions to be answered involve consideration of tangible and intangible aspects, and besides the need to consider *spatial* and *time* dimensions, they require consideration of the *way to invest*, as discussed above.

Introducing the Special Issue

The Second International Conference on Technology Policy and Innovation benefitted from several works that, grounded on empirical analysis at the country level, highlighted the characteristics of issues relevant for local economic development.

The next paper, by Baptista, develops and tests and empirical model aiming at determining the extent to which geographic concentration aids the process of innovation diffusion. The model combines external learning effects with the microlevel determinants of firms' decisions. The arbitrage equation provides the necessary and sufficient condition establishing the time when a firm adopts the innovation. Maximum likelihood estimation is used on data related with the diffusion of two technologies (microprocessors and CNC machine tools) using information on firms within six three-digit manufacturing sectors in the United Kingdom. Date of adoption varies from 1969 to 1980, and firms' characteristics were those of 1981. Ten different geographic regions were considered. Baptista concludes that regional clustering is important for technological innovation diffusion. Further, he is able to establish that this is the result of externalities related to knowledge acting on the diffusion, which work in a way that is identical to knowledge spillovers and agglomeration externalities. Thus, an important conclusion of the paper is that external epidemic effects supplant possible negative forces on technology adoption such as stock (as the number of adopters rises the benefits from adoption decrease) and order (the firm's position in a sequence of adopting firms matters) effects. Rank (firm's characteristics) effects are important, with firm size having a positive impact on adoption. Firm-specific R&D is not a significant factor for adoption.

The paper by Neilsen, explores the relationship between market structure and innovative performance of lawns. The author uses patents as the indicator of innovative performance, and provides an empirical application based on European Patent Office data for Danish firms. A main methodological difference of Nielsen's paper in comparison with other studies that attempt to characterize the response of firms to innovation incentives is that Nielsen does not use, as he says, a "truncated" sample—only firms that innovate—but rather has cases both of innovative and noninnovative firms. Further differences of the Nielsen study include the consideration of a continuous distribution of firm size (instead of dividing firms into classes), and the use of a Probit model (instead of count models). The author finds that firm size and market concentration have counteracting effects on the patenting activity of Danish manufacturing firms; in particular, the effect of market concentration on patenting activity follows a U-shaped curve. Second, the authors find, from a methodological point of view, that modeling patenting activity as a function of firm size and market concentration is subject to selection bias, a weakness of dominant models that relate patents with market structure.

Fontes describes, in the third paper following this introductory paper, the emergence of the biotechnology industry in Portugal, a country generically characterized as an intermediate economy. The analytical subject of interest is the transfer of technology from public research into the productive realm through entrepreneurship. The author finds that the majority of the 18 firms considered were the result (direct of indirect) of research developed in public R&D institutions. The firms, though, were mostly created without any involvement from these institutions, and resulted from the tenacity and energy of an individual or group. A taxonomy is proposed to classify the different types of entrepreneurs involved. Similarly, a taxonomy is also proposed to account for the way in which firms accessed the knowledge generated in the public research organizations. Fontes concludes that "a particular type" of entrepreneur emerges as most important: young, highly skilled, well-connected people, who can match his or her knowledge with the needs he or she identifies in the market. Despite their small number, the author speculates that these firms play an important role as example-setting experiences that can promote technology-based entrepreneurship in a country riddled with the usual problems of a small, intermediate economy: limited internal demand, small and imperfect capital markets, conservatism, and institutional parochialism. Naturally, the policy implications advocated by the author are the counter to these problems: support internationalization, augment public procurement, and raise the public awareness of biotechnology (extend demand), facilitate the access to capital (limit the capital market failure).

In the fourth paper following this introduction, Reguart presents a case study of a Mexican large firm, Vitro, in which the author looks at the process of acquisition technological capabilities in the context of the opening of the Mexican economy. The author describes the trend towards the immersion of Mexico in increasingly open global markets, namely through the country's adherence to GATT in 1986 and, 10 years later, its integration in the NAFTA trade bloc. This process was accompanied, the author argues, to a shift from import-substitution strategies towards export-promotion, which meant that Mexican businesses needed to be able to compete in global and increasingly open markets. A major thrust of the competitive strategy of Vitro to achieve this international competitiveness was the enhancement of the firm's technological capabilities. Before the opening of the Mexican economy, Vitro's technological strategy was focused on efficiency, scale, and vertical integration, mainly through the acquisition or licensing of technologies from leading international firms in the sector. After turning to the export-oriented strategy Vitro adopted international standards of production (implementing a system of total quality management, for example), but, more importantly, the firm revamped and redefined its R&D effort, in an attempt to move from a passive stance towards the technologies and it received to an attitude of seeking to master—and improve and adapt—those same technologies. The author analyzes the empirical information within a conceptual framework that integrates firm and national technology-building capabilities.

In the fifth paper following this introduction, Veloso and Romero explore the roles of incentives, infrastructure, and institutions in the catch-up process on newly industrialized countries by drawing from the example of the evolution of the automotive industry in Taiwan and Mexico. The authors depart from a critique of mainstream neoclassical growth, which is policy neutral, and see in the endogenous growth formulation a more promising guideline for research. Still, both theories, they argue, fall short of what is required to describe the rich interaction between incentive, infrastructure, and institutions, which they strive to do qualitatively, and especially of what is needed for studies at the industrial sector, when policy guidelines are in need. The authors starting point is the observation that the automobile industry was regarded as an engine for catch-up for virtually every country. Still, the outcomes of efforts to promote this industry varied markedly in their outcomes. The cases of both Mexico and Taiwan are ably described, and the authors show that more interventionist government policy in Taiwan may yield better positioning than the outcomes of the Mexico more laissez-faire policy. The authors proceed by establishing a more analytic comparison of the two countries according to the three dimensions chosen: incentives, infrastructure, and institutions.

Kim, in the sixth paper following this introduction, explores the legacy of different policies in Korea—one of the industrialization and building up of technological capabilities success stories of the last decades—using cluster and discriminant analysis applied to wage data. The author's objective is to look for determinants of wage performance of different industrial groups. As a first step, Kim uses cluster analysis to find similar patterns of wage dynamics across industrial sectors between 1970 and 1990. The clustering variable is the year-to-year rate of wage change. After applying this technique to 37 occupational categories, the author identifies five groups with distinctively similar dynamic behavior. The second step in the author's methodology consists of using discriminant analysis to find out the underlying forces that determine each group's dynamics. Finally, by matching the roots of the discriminant analysis with economic time series, the author is able to ascertain the underlying economic forces behind the dynamics of wages in Korea. Kim finds that investment is the most important force, followed by credit availability and, third, by interest parity, and concludes the paper suggesting that it would be important to extend his research to other countries.

The papers described above and included in this Special Issue reflect the most important topics discussed during the LISBOA '98 Conference, but a special note should also be made in terms of the debate kept during the Conference about environmental policy and the sustainable development. This topic is well addressed in the paper by Clift and Wright published elsewhere in this journal (see Volume 65, number 3), which address the relationship between the environmental impact and the value-added chain associated with production. Their study is based on an econometric approach that integrates features of the Life Cycle Assessment conceptual framework. More specifically, the authors attempt to reveal the relationship between environmental impact and added economic value along the supply chain. Their methodology highlights the fact that at each step of the supply chain, when value is created there is also a parallel environmental impact. This coherent build-up of environmental and economic impacts is quantified by the ratio of the environmental impact divided by the value added created, a ratio that exists, at the most elemental level, at each step of the value-added chain, but can also be estimated for products, firms, or sectors. Another representation of the relationship between economic value added and environmental impact proposed by the authors is to plot these two features against each other. The level of convexity of the curve allows for the comparison of the different sectors or products in terms of their relative environmental impact—the authors also make the important point that the curve is likely to be always convex, which means that more environmental damage for little economic gain occurs in the first stages of productions, namely when the usage of basic resources is at stake. Another application that the authors do in their main empirical analysis is to compare the manufacturing of a product (mobile phones) with strategies to minimize the environmental damage at the end of the life of the product. Thus, they show that two possible strategies to deal with mobile phones that are no longer used; reusage or recycling are both less economically attractive than building the original product, but provide, obviously, important environmental gains. The authors conclude that, given the lack of economic incentives for these strategies of minimizing the environmental impact, government intervention is likely to be required. Finally, Clift and Wright note that developing countries are potentially more vulnerable to high environmental damage for little economic gain, because they tend to concentrate on primary resource industries.

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