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Innovation, diffusion and catching up in the fifth long wave

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Abstract

Does the new technological paradigm based on information and communication technologies (ICTs) create new windows of opportunity or further obstacles for catching up countries? The paper discusses this question by taking neo-Schumpeterian long wave theory as the basic framework of analysis. According to this approach, the current rapid diffusion of the ICT-based paradigm marks the initial phase of a fifth long wave period. The first part of the paper focuses on the major changes that characterize the techno-economic system in the fifth long wave, and points out that the new paradigm is leading to several new opportunities for developing economies. If public policies will actively foster the development process by rapidly investing in the new technologies and in the related infrastructures and skills, these new opportunities will indeed be successfully exploited. The second part of the paper shifts the focus to the socio-institutional system, and argues that institutional changes driven by some major actors in the industrialized world are creating a new international regime where the scope and the resources available for State interventions are significantly reduced. The paper concludes by suggesting the existence of a temporary *mismatch* between the techno-economic and the socio-institutional system, which makes the catching up process more difficult for large parts of the developing world.

1. Introduction

Information and communication technologies have started to diffuse rapidly in the economic system in the last two decades. They have originated from the fast technological developments in the semiconductor industry, in the telecommunication sector and, more recently, in a wide range of new services linked to multimedia and the Internet [1]. The convergence of these three streams of technological advances, commonly referred to as ICTs, may arguably constitute the rise of a new ‘technological paradigm’ [2].

A technological paradigm is a set of interrelated and pervasive innovations that increases productivity in many sectors of the economy [3,4]. The new technological paradigm based on ICTs may have important economic effects on growth, wealth and welfare in the near future, and may lead to radical changes in firms’ production structure and organizations, in the patterns of consumption, and in institutional settings.

One major question relates to the consequences that the diffusion of ICTs have for catching up and developing economies. Does the new technological paradigm based on ICTs create new windows of opportunity or further obstacles for catching up countries? The answer to this question is a matter of considerable controversy in the literature on innovation and catching up, and it is rather difficult to discuss because of the fundamental elements of uncertainty, complexity and unpredictability that it entails. It is possible to identify, by and large, two different positions in this respect. The first is a more optimistic stand, which stresses the new windows of opportunity opened up to catching up countries by the creation and diffusion of the new information and communication technologies. This position is founded upon the old argument in the catching up literature of the “penalty of taking the lead” [5].

According to this, developing countries may exploit their backward position by imitating and implementing advanced foreign technologies created by the leader economies, and by rapidly investing in the new technologies. In the new era, catching up countries are less committed to the mass production technological paradigm prevailing in previous decades (in terms of investments in physical capital, machineries, and infrastructures), so that they may find it easier to make the jump into the new technological system based on ICTs. Anticipating future changes in the patterns of global competition, Carlota Perez pointed out already two decades ago the new possibilities open up for developing countries in the era of ICTs because for them, she argued,

it is possible to attempt a direct entry without going through the technological stages it leaves behind [...]. The new technologies allow 'leapfrogging' for some of the countries that do not carry the inertia of the previous industrial structure [...] The transformation in the relative cost structure changes both comparative advantages and comparative disadvantages. For each country, this implies a fundamental rethinking of its relative advantage position within the new techno-economic paradigm to identify new possibilities [6, p. 457].

The rapid catching up process of Asian NICs (Newly Industrialised Countries, such as Korea, Singapore and Taiwan) in the last few decades shows that the opportunities opened up by the diffusion of the ICT-based paradigm can indeed be successfully exploited by catching up countries, provided that the development strategy that they pursue emphasizes the need to actively invest in the new technologies and in the related infrastructures and skills. The tigerish growth of China and, to a less extent, India in the last decade provides more recent examples of the importance of ICT-related manufacturing and service activities for the catching up process.

These successful cases, however, contrast with the general pattern of increasing disparities in income and technology levels that the world economy has experienced in the last few decades [7,8]. A large group of less developed economies, mostly in Africa, Asia and Latin America, have in fact been growing at a rather slow pace, and the technology and income gap has therefore significantly widened for many of them. Several countries have very low levels of technological capabilities, infrastructures and education, and consequently find it hard to exploit their backwardness position by imitating ICT-related foreign advanced technologies.

There thus exists a second position in the catching up literature that is less optimistic with respects to the current and future prospects for innovation- and imitation-based growth. This is founded upon a strand of historically oriented studies on technological development, growth and catching up [9,10,11]. Historical evidence indicates that economic development is far from being an automatic and easy process, and that it is on the contrary very demanding and costly. This second stand therefore looks with greater concern at the social and institutional factors that may hamper the catching up process. In this respect, it is argued, the new paradigm based on information and communication technologies is creating as many new obstacles for development as the opportunities it opens up. The process of creation of new technologies and its international diffusion are currently more difficult to exploit for catching up countries, due to the greater requirement in terms of skills, competencies and capabilities that modern ICT-based global competition requires [12]. In particular, the international diffusion of technologies, which has been a major factor of catching up in previous decades,

seems to have become more 'difficult' and demanding over time. [...] This may be a reflection of the radical technological change in the last decades, with ICT-based

solutions substituting earlier mechanical and electromechanical ones, and the derived change in the demand for skills and infrastructures [13, p. 1303].

The present paper conceives these two arguments as largely complementary to each other, rather than opposite, as they look at different relevant aspects of the catching up process. By taking these two previous positions as a conceptual starting point, the paper aims at discussing the new opportunities and further obstacles that the emergence of the new ICT-based technological paradigm creates for catching up countries.

The discussion will take the neo-Schumpeterian long wave theory as the basic framework of analysis. Neo-Schumpeterian long wave theory flourished in the 1980s [4,14], following the previous seminal work of Schumpeter on business cycles [15].¹ According to this approach, the capitalist system is constituted by two related sub-systems, the techno-economic and the socio-institutional. It is the joint evolution of these sub-systems to determine the ‘mode of development’, and consequently the rise and fall of long waves in the long run. In particular, neo-Schumpeterian long wave theory explains countries’ long run macroeconomic performances in terms of the diffusion to the whole economic system of families of interrelated radical innovations, that is the technological paradigms. When a new technological paradigm emerges, there is a big impulse in the techno-economic sub-system to adopt the new best practice technology with high profit prospects. However, by its own nature, the techno-economic system is more rapid to adopt changes, while the socio-institutional one may take a longer time before introducing the modifications required by the new

¹ Since the beginning of 1980s, *Futures* has published several articles contributing to the debate on long wave theory, and particularly to its neo-Schumpeterian version [14,16,17]. Dator [18] reviews the debate on long waves with special emphasis on the articles appeared in *Futures* in the 1980s and 1990s. More recent contributions include Linstone [19] and Dewick et al. [20]. For a discussion of the relationships between this and other theoretical perspectives in innovation studies, see Castellacci et al. [21].

technological style. The mismatch between the two systems may retard the large-scale introduction of the new paradigm, precisely because some social, organizational and institutional changes are necessary before it can diffuse to the whole economy [22]. According to several accounts (e.g. [2]), the current rapid diffusion of the ICT-based paradigm marks the initial phase of a fifth long wave, and thus provides new growth opportunities for many countries in the world economy. However, what matters for long run growth and development in the fifth long wave is not the pace of ICT creation and diffusion as such, but rather the dynamic complementarities existing between the ICT paradigm and a set of other socio-institutional characteristics that greatly shape and affect the growth process.

Following this neo-Schumpeterian perspective, the major question examined in the paper, on the consequences of the emergence of the ICT-based paradigm for catching up countries, will be rephrased by discussing whether there currently exists a good match between the techno-economic and the socio-institutional system, and what the implications of this are for developing countries.

The contribution that the paper intends to give to the neo-Schumpeterian long wave literature is twofold. First, it will bring together several relevant aspects characterizing the new ICT-based technological paradigm, and try to provide an integrated view of the emerging ‘mode of development’. Secondly, it will apply the neo-Schumpeterian long wave theory to the international dimension, and use it to discuss the opportunities and challenges that catching up countries face in the fifth long wave.²

² With a few exceptions [4,23,24,25], in fact, long wave theory has never focused on the international dimension. The application of this theoretical perspective to the analysis of growth rate differences across countries is important because it points to the *paradigmatic* nature of the process of innovation and catching up. The latter process is deeply rooted in a given historical context, and can therefore be better understood by looking at the emergence and diffusion of technological paradigms, and at the rise and fall of long waves.

The paper is organized as follows. Section 2 will describe some major features that characterize the ICT-based techno-economic system, the new windows of opportunity that these open up for developing countries, and the new challenges that these create for policy makers to foster and sustain the catching up process. Section 3 will then discuss some recent trends and changes in the socio-institutional domain, particularly in the international regime, and the implications that these have for public policies in catching up countries. Finally, section 4 will conclude the paper by pointing to the existence of a *mismatch* between the techno-economic and the socio-institutional system. The former, in fact, requires new and more active forms of State intervention to sustain the catching up process, while changes in the latter tend to decrease the scope and the resources available for public policies.

2. The ICT-based techno-economic system

Information and communication technologies are diffusing rapidly in the economic system. According to neo-Schumpeterian theory [2,26], the current rapid diffusion of the ICT-based technological paradigm is one major factor leading to the rise of a fifth long wave period, which will span for the next few decades. A widespread adoption of ICTs, in this view, will lead to radical changes in the patterns of production and distribution in the near future, and these transformations are likely to determine important consequences not only in the industrialized world, but for catching up countries as well. This section focuses on the major characteristics of the changing techno-economic system, and, relatedly, on the new windows of opportunity opened up for developing countries, and on the new challenges that policy makers have to face to sustain the catching up process in the fifth long wave.

2.1 A more intangible and information intensive production

Differently from the previous mass-production technological paradigm, which had a strong energy and materials intensity [10,11], the new paradigm based on ICTs is characterized by great *information intensity* [2,6]. An important consequence of this is the rise of importance of *intangible* assets and productive factors [27]. These changes towards an information intensive and intangible knowledge-based economy may open up new windows of opportunities for catching up countries, and, consequently, determine new challenges for policy. Three main aspects appear to have a particular importance in this respect.

First, the knowledge-based economy is less dependent on raw materials and natural resources.³ This makes the catching up process possible even for countries that are not well endowed in terms of natural resources and raw materials. Important changes in the patterns of comparative and competitive advantages may occur, as *human skills and knowledge* become the key factors to compete in the international arena.

However, as human skills and knowledge increase their importance, there is the growing risk that countries with better levels of education and human capital may use them to rapidly improve their economic performance, while less developed countries find it more difficult to catch up by cumulatively improving their knowledge assets. A large literature in innovation studies has in fact shown that the process of creation of technological knowledge is dynamic and cumulative [29,30], so that knowledge-based growth may risk of leading to growing disparities between rich and poor countries. In

³ Berkhout and Hertin [28] observe that the progressive substitution of information for materials and energy has been discussed in the literature by using two similar concepts, i.e. 'de-materialisation' and 'virtualisation'. According to them, the former term may be a more precise characterization of the current trends in the knowledge-based economy, as de-materialised products and services do not completely substitute the traditional devices, but more frequently tend to complement and integrate them.

this respect, then, the catching up process needs to be strongly sustained by education and training policies, aimed at enhancing technological capabilities and at improving absorptive capacities of follower countries. Education and training policies have always been important to foster economic development, but in the modern knowledge-based economy tend to become an even more relevant instrument for policy makers to sustain the catching up process.

A second window of opportunity is provided by the fact that besides the traditional form of infrastructure, based on tangible assets and communication channels, the new ICT-based technological paradigm is increasingly dependent on an intangible type of infrastructure and communication system, based on high speed transmission of data.

The name we now give to this emergent information infrastructures is *cyberspace*, the electronic culture of computers and networks, information systems and software, that exists on the Internet. Cyberspace [...] is to the fifth long wave what railroads were to the third and highways/airways have been to the fourth [31, p. 307].

A recent important technological trajectory in the development of the cyberspace is the rapid diffusion of wireless communication channels, such as mobile phones and wireless Internet connections, whose supporting infrastructure is based on satellite communication and mobile telephone networks. In future perspective, we may expect these virtual networks and the related new infrastructures to complement and, to a large extent, even substitute the traditional infrastructures and communication channels.

These changes may provide new opportunities for countries with a low level of traditional infrastructures, if they will be able to heavily and rapidly invest in the new technologies of communication, particularly in wireless-related devices [32]. There exist several examples of information and communication technologies that have been

recently developed in the Indian context and that have the potential to rapidly diffuse in the developing world: the 'Cor-Dect' (a cheap wireless local loop product), the 'simputer' (a shared computing device for multiple users in a rural community), and the 'n-Logue' (which provides telecom and Internet service to rural areas).⁴

What these successful cases indicate is that ICTs can indeed provide new opportunities for economic development in catching up countries. The new investments that are necessary to build up and develop the new infrastructures, though, have to cover large initial costs that may be difficult to sustain for local firms. An active effort of the State, and particularly of the public system of S&T, may therefore be of great importance in sustaining this process, especially in the initial phase when foreign advanced technologies need to be adapted to local contexts.

Thirdly, and related to the previous points, a catching up country that is less committed to the previous technological paradigm, in the sense that it has invested less resources in infrastructures and physical capital related to the technological system prevailing in previous decades, may have better opportunities to rapidly transform its productive structure towards the new activities. In addition, the fixed investments required to enter the new ICT-based paradigm are lower than those needed to compete in the mass production technological system [6]. The information intensive and intangible characteristics of the knowledge-based economy may thus enable a more rapid process of structural change, and determine possible advantages for latecomers. The opportunities arising from rapid structural change are not confined to the emergence of ICT-related advanced manufacturing and service

⁴ Several articles have recently appeared in *Futures* on the relationships between ICT-related infrastructures and economic development. For an interesting discussion of some of the successful cases and of the new opportunities that they provide for the growth of India and other developing countries, see [33] and [34]. For a related discussion of the need to adapt ICT technologies and infrastructures to different local contexts, and particularly that of African countries, see [35] and [36]. Taking a longer-term perspective, Rimmer [37] presents a study of the important role played by infrastructural investments for the catching up process of China.

industries, but refer also to the productivity gains that the use of ICTs may lead to in traditional and low-tech sectors, which still account for a large share of production and employment in many catching up countries [38].

However, the rapid process of transformation of the economy may lead to greater risks of technological unemployment, i.e. to the possibility that workers that were previously employed in primary or low-tech manufacturing activities find it difficult to improve their skills and competencies in a relatively short period of time, so to be employed in the more technologically advanced sectors [39,40]. It is therefore important that the State undertakes an active effort to promote training and re-training policies with the purpose of enabling a more rapid shift of labour resources towards the more advanced activities [12].⁵

2.2 The flexible production system

The new ICT-based paradigm determines a shift from the mass production to the *flexible production system*. The mass production system, the dominant form of production during the Fordist era, was characterized by the exploitation of economies of scale linked to plants' size, and by a type of predominantly producer-defined products [41,42]. The adoption of ICTs in the productive process, it has been argued, determines important changes in the production patterns, and favours the shift towards the flexible production system. In the latter, economies of scope and of specialization based on flexibility replace the more traditional economies of scale based on plants'

⁵ The catching up process that China has experienced in recent years is frequently pointed out as an example of a rapid process of structural change, with a massive shift of cheap labour supply from primary activities to traditional and low-tech industries. The most recent developments, however, indicate that the rapid technological upgrading of manufacturing industries is progressively leading to a greater importance of high-tech sectors in the economy, which require highly skilled labour that it is not easily available in the Chinese labour market. This may possibly constitute a bottleneck for the further expansion of the economy in the near future, which Chinese public authorities and foreign firms investing in the country should both look at with concern (The Economist, April 16th 2005).

size; real time and on-line monitoring of demand substitutes the previous periodic planning of production; and the productive system tends increasingly to be user- rather than producer-defined [2,6,43]. These transformations are the results of flexible production capabilities and of greater information intensity of equipments and products.

As a consequence of these changes, the accumulation of physical capital, which has traditionally been regarded as the major factor of growth in mainstream growth theory, becomes a relatively less important engine of economic development in the modern knowledge-based economy. The latter is in fact more dependent on human skills and competencies, user-producer interactions, learning by using and learning by interacting mechanisms, and the related investments in intangible and advanced knowledge assets [27].

This opens up new possibilities for technological and economic catching up for those countries that will be able to exploit the advantages of the flexible production system [44]. An important push in this direction must be provided by active efforts of the State to improve consumers' and users' competencies, which become a fundamental factor of competitive advantage in the knowledge-based economy. It is important, more in general, that public policies in catching up countries adopt a systemic understanding of the innovation process, which naturally leads to focus the attention on user-producer interactions. A systemic understanding of innovative activities is in fact well established in the academic and policy debate in more advanced countries, particularly in Europe, but its wider diffusion to the developing world has not been realized yet [21,45].

2.3 The rise of the service sectors

Strictly related to those discussed above, another major trend in modern capitalism is the *rise of the service sectors*. These account now for about two thirds of employment in most industrialized countries, and, more importantly, they are playing a more relevant role for the creation and diffusion of advanced knowledge [46,47]. In fact, while service industries have traditionally been conceived as productivity laggards and as passive adopters of the advanced technologies developed in manufacturing industries (which were often considered as the main engine of growth, see [48]), more recent trends indicate the increasing role that services are taking in the process of technological and economic catching up [13].

As the process of structural change goes on, service industries assume greater significance and an increasing share in the overall production and employment not only in major industrialized countries, which are leading these trends, but in catching up countries as well. India is a well-known example of a developing economy where ICT-related advanced services are playing an increasingly relevant role in the catching up process. Districts like Bangalore, Hyderabad and Gurgaon have become hubs for IT services (e.g. software development, call centres, backroom operations) that have attracted many large foreign companies [34,49]. Could the Indian experience be generalized to other developing countries in the near future, and what are the reasons to believe that this may be the case?

The rise of services may provide new windows of opportunity for follower countries for at least three main reasons. The first is the strict relationship between the development of ICTs and the rise of services [50,51]. Many service activities have recently improved both the efficiency of the productive process and the quality of the provided service by adopting ICTs in their back-off operations [47,52]. Barras [53]

pointed out that the use of information and communication technologies in services may be described by a “reverse product cycle model”, where ICTs lead first to improved efficiency, then to improved quality, and, eventually, to totally new services. The reverse sequence of the product cycle for the case of services as opposed to manufacturing industries has important implications: standardisation becomes less important, while the ‘customisation’ of services takes greater significance over time [54]. Customisation implies that services are designed and improved in strict relationship to the clients’ and users’ needs, and that entirely new services arise from user-producer interactions (so-called ‘ad-hoc’ innovations, see [55]).

Thus, similarly to what observed above in relation to the characteristics of the flexible production system, human skills and competencies, user-producer interactions, learning by using and learning by interacting mechanisms become the dominant factors of competitive advantages in the service economy. This opens up new opportunities for catching up countries, provided that public policies will favour the exploitation of this potential by improving users’ competencies, and by sustaining and promoting user-producer interactions, which is a key policy requirement according to a systemic understanding of the innovative process.

The second reason why the rise of the service sectors may provide new windows of opportunity for developing countries is the limited appropriability of innovation in service activities [46]. The conditions of appropriability in service industries are to a large extent different than those prevailing in manufacturing sectors, precisely due to the intangible nature, the high information content, and the closer user-producer interactions that characterize service activities. These features make it more difficult to appropriate the benefits of innovative activities in services, and traditional forms of

protection, such as patents, become therefore less effective. While this may hinder the innovative process by decreasing the incentives to innovate (the “incentive effect”), the other side of the coin is that the scope for imitation and knowledge diffusion may be greater in the service economy, both within services and towards manufacturing industries (the so-called “efficiency effect”; see [56]). The latter mechanism may turn out to be an important source of aggregate productivity growth and structural change as the service sectors expand their share of total production and employment.

Catching up countries may exploit these new opportunities by imitating the advanced services produced in the leader countries, as well as by enhancing the diffusion of knowledge across sectors within the economy.

The risk of this development strategy is obviously that of decreasing the incentives for innovators, thus making the national system of innovation too dependent on foreign advanced technologies. A sustainable catching up process must therefore be accompanied by public policies aimed to provide incentives to innovative and R&D activities of national firms, to sustain, more in general, the development of local entrepreneurships, and to design an appropriate system of regulation of intellectual property rights.

There is also a third important characteristic of the service economy that may turn out to have important consequences for catching up. In service industries, it is frequently argued, besides technological capabilities, non-technological types of knowledge are important as well [46,47]. Non-technological types of knowledge are those that do not have an ultimate scientific and engineering base. One such types of knowledge is the ability to organize and re-organize productive activities in a complex and uncertain environment, namely organizational capabilities [57]. Other non-technological types of knowledge that constitute important factors of competitive advantages in many

service sectors are the specific and context-dependent knowledge about markets, about consumers' habits and tastes, about national institutions and regulations, and so on. Gallouj points out that improvements in these types of knowledge and capabilities may lead to a sort of 'expertise-field innovation', whose result is the "opening up of new markets, the diversification (internal and external) or renewal of product ranges, and the creation of a competitive advantage or monopoly in terms of knowledge and expertise" [58, p.133].

An important example of this type of innovation is provided by 'knowledge intensive business services' (KIBS). These are often considered as a 'second knowledge infrastructure' in the knowledge-based economy. They include the business services that are founded upon highly specialised and context-specific knowledge in a wide range of diverse activities (e.g. administrative, legal, marketing, Web and Internet, software and computer services, information and training services; [47]). According to the *Community Innovation Survey*, KIBS firms have been among the most active innovators in the European economy in the 1990s. Consultancy services, in addition, turn out to be the second most important source of technology for manufacturing firms in Europe. There is therefore robust empirical evidence, at least in the context of the industrialized world, supporting the idea that KIBS play an important role not only for the direct production of specialised knowledge, but for its rapid diffusion as well. Catching up countries may thus exploit these new opportunities by trying to rapidly promote not only science- and engineering-related technical knowledge, but also non-technological types of knowledge, which may eventually favour the development of modern and competitive KIBS. Here again, public policies have an important role to play in this respect: first, because the public system of basic and advanced education has the concrete possibility to develop and to enhance the education level of the

workforce; secondly, because the State may actively enable the development of a modern training and re-training system in the private sector, so to accelerate the process of structural change towards the new knowledge intensive service activities.

2.4 Organizational changes: the network-firm and the e-commerce

Besides the several technological changes described above, the new paradigm based on information and communication technologies is characterized by some important *organizational changes* as well. One of these, arguably the most relevant, is that ICTs favour a stricter connection and a more rapid communication between economic agents situated in different locations. Castells [59] and Freeman and Louca [2] argue that ‘networking’, both within the firm and in its external relations, may turn out to be a major feature of the new technological paradigm. Networks take different forms, such as partnership between firms, their cooperation with customers and users, or with subcontractors and employees, and they also favour the integration of different functions within the same firm [6]. ICT-based networking is characterized by an increased speed of communication, and by a rapid access to new and wider sources of information. This gives great advantages to the participants of a network, which may exploit a much greater pool of knowledge than it would be the case if they were operating as individual agents.

Organizational changes are not only important for the supply side of the economy, but for the demand side as well. ICTs make it possible the on-line monitoring of demand, which substitutes the previous practice of periodic planning and makes it possible the development of the flexible production system, where users and consumers, as discussed above, take an increasingly important role. The current rapid development of e-commerce, in addition, may in the future determine radical transformations in the

distribution chain, and, consequently, in the patterns of competition in global markets [60].

It is rather difficult to predict the implications of these organizational changes for the development process. On the one hand, ICT-based networking between firms may open up new opportunities for the developing world to gain access to new and wider sources of advanced knowledge in global production chains, provided that private enterprises in catching up countries will be able to develop the advanced skills and capabilities that are required to cooperate and to participate in networks with more advanced firms in the leader countries. The diffusion of e-commerce may also provide new opportunities for emerging markets, as it may favour the commercialisation of products and services produced in peripheral regions of the world economy. Without the possibilities offered by web-based virtual shops, in fact, these peripheral products and services would simply be not visible in the industrialized world, and would therefore be excluded from the competition process in the international arena.

On the other hand, however, these opportunities are rather difficult to exploit, and they may very well turn out to be factors of greater competitive advantage for private firms of the leader countries. In fact, the network-type of organization of the productive process, as well as the e-commerce-related organizational changes on the demand side, do not per se overcome the issue of power relations within the networks [2,61]. If some of the participants to a global production network have an initial advantage in terms of, say, advanced capabilities, resources and economic power, then the network may turn out to be a vehicle of cumulative growth where the strongest participants will increase their power and market shares over time, while the less endowed participants will shrink [31]. This risk is in fact real if we think of the great power gained in recent decades by multinational enterprises (MNEs), which are

major actors in the promotion and diffusion of ICT-based global production and distribution networks. Thus, the new opportunities offered by the rise of the ‘network firm’ and by the diffusion of e-commerce may be better exploited by catching up countries if their Governments will play an active role as regulators of the competitive process by promoting greater competition and enhancing efficiency, particularly in those markets where the extraordinary power gained by MNEs determines an oligopolistic structure and an unbalanced relation of power within firms’ networks [62].

2.5 The globalisation of technological activities

The important changes described above occur in the context of the increasing interdependence between national economies, namely economic globalisation. One of the important transformations that the latter is leading to in the techno-economic sphere is the *globalisation of technological activities*. This refers to the fact that “the generation, transmission and diffusion of technologies is increasingly international in scope” [63, p.121]. The main reason why innovative activities are becoming more global in scope is that technical feasibility has increased significantly in the ICT-based paradigm, while economic costs have been dramatically reduced [2]. Following Archibugi and Michie [64] and Archibugi and Iammarino [65], the globalisation of innovative activities can be described by using a three-category taxonomy. Based on the latter, this section considers the implications that each of the three channels of globalisation of technology may have for catching up countries, in terms of new opportunities as well as new challenges for policy.⁶

⁶ On the consequences of the globalisation of technological activities for the environment, see the recent study of Miozzo et al. [43], which focuses on past technological trajectories and future trends in the textiles and chemical industries.

The first channel of globalisation of innovative activities is the *international exploitation of technology*, which may be regarded as the technological equivalent of international trade flows. This occurs when a new technology is exported in order to exploit the relative benefits in the world markets. The innovation being exploited in international markets can be either embodied in exported high-tech products, or in disembodied form (e.g. sale of licences, patents and know-how). Empirical evidence indicates that both aspects have dramatically increased in the last decades [66,67].

The trends towards a global ICT-based competition may have important implications for catching up. On the one hand, some small open economies have been able to catch up rapidly in the last few decades by shifting their productive structure and specialization patterns towards the technologically most progressive industries (e.g. electronics). These countries, such as Northern EU (Finland, Ireland) and Asian NICs (Korea, Singapore and Taiwan), have greatly and rapidly improved their production capabilities in ICT-related technologies, and this has made it possible for them to become competitive in global production networks, and to exploit economies of scale in foreign markets. The export-led and knowledge intensive characteristics of the catching up process in these countries have led to a great deal of interest in this type of development strategy, strongly based on large firms' high-tech leadership in global production and distribution networks. Recent research has shown, in particular, that these countries have been able to exploit the windows of opportunity provided by the development and diffusion of the ICT-based paradigm through the active implementation of public policies that have rapidly improved the education level (particularly tertiary education in science and engineering), increased the resources devoted to R&D expenditures, upgraded the technological infrastructures, expanded the employment opportunities for highly educated workers, and targeted emerging

and progressive sectors through industrial policies, especially in the initial phase of the catching up process [12,68].

On the other hand, seen from the point of view of the host economy, this first channel of globalisation of innovation may provide new opportunities for catching up through imports of high-tech product and machineries, as well as by attracting FDI from more technologically advanced countries. These channels of international technology diffusion have frequently been pointed out as possible sources of knowledge spillovers and growth of host economies. A well-known fact pointed out in this literature, though, is that the process of technology transfer towards less developed economies is not an easy and automatic outcome, but it requires the upgrading of capabilities and absorptive capacities of local firms. An active involvement of the State in the process of upgrading of domestic technological capabilities, skills and infrastructures is therefore a fundamental requirement for catching up [69]. Besides supporting the process of upgrading of local absorptive capabilities, public policies in developing countries can also spur international technology transfers by providing incentives to selected FDI and to their learning-enhancing modes of operation, and by negotiating on imports, IPRs and licences with foreign firms [70].

The second channel of globalisation of innovative activities is the *global generation of technology*, i.e. the process by which MNEs internationalise their R&D activities. This can be regarded as the technological equivalent of FDI, and it is realized either when MNEs move part of their R&D labs abroad, thus setting up global research networks, or when they acquire existing R&D labs in host countries [71]. Empirical evidence shows that even this second channel of globalisation of innovation is assuming greater importance over time [66,72].

Developing countries have the possibility to exploit the global generation of technology by trying to attract investments related to R&D activities of foreign MNEs that could have, at least in principle, a positive effect on local firms by enhancing their technological capabilities. The learning effect related to this second channel, however, can only be exploited if catching up countries have a sufficient level of infrastructures and educated workforce, which would make it possible to attract foreign R&D labs and to enjoy the relative benefits in the host economy. The existence of a few successful cases (e.g. Texas Instruments and Microsoft locating part of their R&D labs in the high-tech district of Bangalore, India) points to the fact that these new opportunities are better exploited in countries where public policies actively favour the creation of a dynamic learning environment. Public policies in this respect can take a variety of different forms, such as providing real incentives to the location of new innovative activities with foreign capital, upgrading S&T infrastructures and institutions, supplying qualified workforce, and associating MNEs centers to hubs of specific knowledge and industrial firms located in host countries [65].

The third channel of globalisation of new technologies is constituted by *techno-scientific collaborations* [63]. These can be undertaken either by private firms (e.g. through joint ventures for innovative projects, or through agreements with exchange of technical information and/or equipment), or by the public research sector (e.g. through international scientific projects and R&D networks, international flows of students and researchers, etc.). Here again, empirical evidence indicates a rapid increase in the internationalisation of both private research and public science [71,73]. Differently from the previous two channels of globalisation of innovation, which entail an increasing process of competition between countries in the world economy,

techno-scientific collaborations enable learning, knowledge diffusion and economic growth in both countries participating to a joint venture, and thus favour the emergence and intensification of new forms of collaboration in the international arena. In such a positive sum game, international cooperation is increasingly becoming a major source of competitive advantage, and catching up countries have therefore the concrete possibility to exploit this opportunity to augment their stock of advanced scientific and technological knowledge.

For a developing economy, the best way to do so is to enhance domestic competencies, capabilities and infrastructures, so to increase its effective participation to the new forms of collaborations in the global arena. Policies at the national level may use several different instruments to achieve this objective, such as promoting international scientific projects and exchange programmes, increasing student flows to more technologically advanced countries (and giving them real incentives to go back home after the end of their education period abroad, so to avoid risks of brain drain), participating to international organizations (for the development of S&T, and for technical and industrial collaborations), developing infrastructures for technological collaborations (e.g. scientific parks, consortia, etc.), and promoting University-industry linkages [70].

Considering them together, the three channels of globalisation of technological activities provide new opportunities for catching up countries, at the same time as they lead to greater risks of marginalization and increasing disparities in the near future. The crucial point is that, as the rules of the game change and the process of competition in the international arena becomes more demanding for developing economies, public policies must take an increasingly important role for sustaining

catching up and knowledge-based growth in the globalising learning economy. As pointed out in an article previously appeared in *Futures*,

A globalised economy is transforming the landscape for the generation and diffusion of innovation, but this does not appear to decrease the importance of national characteristics nor, even less, of national institutions and their policies. On the contrary, by magnifying the potential costs and benefits which will result from any country's competitive advantage or disadvantage [...] globalisation will increase the impact that national policy will have on domestic living standards [64, p. 122].

< Table 1 here >

3. Public policies and the international regime of regulation

The previous section has focused on some of the major characteristics of the new ICT-based technological paradigm. Table 1 summarizes the main changes in the patterns of production and distribution that characterize the so-called *fifth long wave* period. In a nutshell, the economy is becoming more information intensive, more based on intangible assets and advanced knowledge and skills (both technological and non-technological), and progressively more dependent on new and emerging services and less on traditional manufacturing activities. Human knowledge and capabilities, and more specifically firms' technological knowledge and organizational capabilities, and advanced users' competencies, are increasingly becoming the crucial factors of competitive advantage in the international arena. Relatedly, knowledge-based competition in the global economy requires a rapid adaptation to the new forms of collaboration and competition that the changing organizational patterns (e.g.

networking and e-commerce) and the increasing degree of globalisation of innovative activities are leading to.

All of these changes open up new opportunities for developing countries, as these could activate a process of catching up by heavily investing in the new activities and related skills and infrastructures, while the role of physical capital accumulation, older and more traditional infrastructures, raw materials and natural resources become less important over time. However, while the patterns of comparative advantages and comparative disadvantages tend to be drastically redefined, important challenges arise for catching up countries. The new technological paradigm is more requiring in terms of skills and of advanced education levels, so the risk is that countries that will not rapidly invest to improve human capabilities and skills will fall further behind [12,13].

The previous section has argued that a key role in this respect must be played by public policies, which have indeed the concrete possibility to actively sustain the process of technological and economic catching up. In the fifth long wave, national science, technology and innovation policies, and more generally economic and industrial policies, have an even greater scope than before for fostering development [2,64]. The claim that public policies can effectively foster the development process is well recognized in the literature on catching up, and it is supported by a wide range of historical studies on the successful experiences of catching up countries in the last two centuries [5,9,74,75].⁷

⁷ These historical case studies have in fact shown the important role played by public policies, also in interaction with market forces, in the development process. A first important example refers to the role of public technical schools in promoting scientific and technological catching up of Germany during the second half of the 19th century [5]. A second case is that of Japan in the post-war period, where the Ministry of International Trade and Industry (MITI) played a fundamental role in promoting a long-term development strategy based on technological progress [76]. A more recent example is provided by the rapid catching up process of Asian NICs (Korea, Singapore and Taiwan), where public policies (education, R&D, infrastructures, and industrial policies) have been important for sustaining structural

Paradoxically, however, while the current trends and transformations in the techno-economic system discussed in the previous section are increasing the need for State policies to sustain the catching up process, recent changes in the socio-institutional system have significantly decreased the scope for public interventions. In fact, institutional changes in the international regime of regulation have assigned to market forces an increasing role in the development process, while the possibilities and the resources that the State has to concretely drive and affect technological patterns and economic performance have been dramatically reduced.

The expression commonly used to indicate this set of changes in the international regime is ‘Washington Consensus’, which indicates the type of neo-liberal ideology and the related set of policies that assume that the best strategy to obtain economic development is through the free operating of market forces. Let us discuss in turn the major institutional changes that have characterized the international regime in recent decades, with special focus on the Washington Consensus type of development strategy, and the consequences that this has determined for public policies in catching up countries.

A first important trend is the progressive *liberalization of trade*, and in particular the rise of long-term investments by MNEs. This is one major aspect of the process of economic globalisation, although this is arguably not a new trend but rather the continuation of a secular transformation of the world economy towards greater interdependence across countries [79,80]. In recent decades, trade liberalization has been promoted through multilateral agreements, where international organizations

change and macroeconomic growth [68]. For a broad discussion of the role of public policies in the developing world, see [77]. Clark et al. [78] discuss the same topic with special reference to the case of biotechnology.

such as the WTO (former GATT) play a central role, as well as bilateral negotiations between trading partners [81,82]. The progressive liberalization of trade tends to increase the scope for the international diffusion of knowledge and technologies, and this may obviously provide new opportunities for catching up countries.

However, imitation of foreign technologies is a costly activity and a very demanding process, and not all of the follower countries have the necessary absorptive capacities that are necessary to exploit their backward position in international trade [10,83,84].

In this respect, public policies are necessary for catching up countries to enhance local capabilities and absorptive capacities, otherwise the advantages of the free trade regime will only be exploited by the more technologically advanced economies.

The crucial point here is that while multilateral and bilateral trade agreements increase the scope for the international diffusion of knowledge, at the same time they constrain the possibility that national policies have to protect infant and emerging industries, which would be needed to enhance local capabilities and absorptive capacities during the early stages of the new industries' life cycle. Forces making for liberalisation, in fact,

constitute a formidable web of constraints on governments mounting industrial policy. [...] Market forces cannot substitute for the role of governments in developing and promoting a proactive industrial policy [...] Catch up through infant industry promotion has always been the bedrock of industrial development, and as yet no clear alternative has presented itself [69, pp. 457-459].

In addition to this well-known long-term argument, there is also a short-term one: if inefficient and/or emerging industries in developing countries will lose market shares due to the competition of foreign advanced sectors, their negative performance will result in a loss of employment and, hence, aggregate demand [85]. This, in turn,

may have a negative impact on productivity growth, and may therefore possibly lead to a vicious circle [86]. The free trade regime, therefore, presents as many challenges for developing countries as the opportunities it creates.

A second important trend is the *liberalization of worldwide financial capital movements*, which increasingly take the form of short-term speculative transactions. In general terms, the role of financial capital for innovation, growth and catching up is certainly important, and it has been extensively investigated.⁸ One common argument is that free capital movements provide with a greater potential role for external finance in the catching up process, both in the form of foreign direct investments and of lending. This has been an important factor for the rapid growth of Asian NICs, and particularly for Korea, Singapore and Taiwan [12].

The liberalization of worldwide financial capital, however, may also lead to great risks, as catching up countries become increasingly dependent on foreign capital and, hence, more vulnerable to international financial crisis, as the 1997-1998 crisis in East Asia illustrates [90]. More generally, the problem is that worldwide short-term speculative transactions may displace resources from long-term investments in productive activities. Recently, financial capital movements have grown so big that monetary authorities and national central banks have to devote significant efforts to keep monetary variables and financial markets under control, and consequently find it increasingly difficult to pursue other important goals such as promoting investments in productive activities, expanding economic growth and favouring the creation of new employment opportunities. When speculative movements and inflationary

⁸ A seminal study is that of Gerschenkron [9] on the role of the banking system for industrial development. More recent contributions, including discussions of the relevant literature, can be found in [87] and [88]. Perez [89] analyses the same topic within a neo-Schumpeterian framework of analysis.

pressures lead monetary authorities to the adoption of tight monetary policies, in fact, the resulting increase in interest rates slows down investments, and it consequently hampers the processes of capacity building and capital accumulation that sustain growth.⁹

A third relevant aspect that is currently characterizing the international regime is the *new system of intellectual property rights* (IPRs). According to Granstrand [91], recent changes in the international IPRs system are leading towards a “pro-patent era”. One major factor driving these changes is, first of all, the shift in US national policies related to the patent system during the 1980s and 1990s [92]. Contrary to what was the norm in previous decades, less emphasis is now given to the static efficiency losses that the existence of large firms’ monopolies and market dominant positions may induce, and more attention is given to the dynamic efficiency gains that a well-organized patent system may lead to by promoting innovative activities. An important role in this shift has been played by the interests of MNEs, which have gained more and more power in recent decades, and have actively been pushing towards a strengthening of the IPRs system to protect their market shares and dominant positions.

However, the new IPRs era is, first and foremost, the continuation of a long run secular trend towards increasing harmonization and standardization of national patent regulations through international conventions and agreements. The most important recent step in this direction is the TRIPS agreement established in 1994. According to this, IPRs matters shift from the UN-related WIPO (World Intellectual Property

⁹ With reference to the 1997-98 financial crisis in East Asia, Stiglitz [90] observes that the countries that followed this type of IMF-prescribed tight monetary (and fiscal) policies, such as Thailand, Indonesia and (later) Russia, are those that experienced the most damaging effects of the recession. On the contrary, countries like Korea, China and Malaysia, that reacted by adopting more orthodox counter cyclical expansionary policies, managed to recover earlier.

Organization) to the GATT-WTO sphere of influence, where the US and other major economic powers have a more direct influence. IPRs issues thus start to be considered as part of trade agreements and negotiations, where industrialized countries have the interest to promote a more rigid system of protection of intellectual property to developing countries, and where they can exert a much stronger influence and negotiating power.

Catching up countries find therefore increasingly difficult to adopt national IPRs regulations different from those established by multilateral or bilateral agreements at the international level, and this may seriously hamper the process of international diffusion of technology and the related capability building in the developing world [8,69]. All in all, the more restrictive character of the new regime reduces the scope for national policies, makes innovation- and imitation-based growth more difficult for catching up countries, and it represents therefore one major factor leading to the widening of the technology gap that the developing world has experienced in recent decades.

Fourthly, there has increasingly been in recent decades a strong pressure for catching up countries to decrease public spending, budget deficits, and, more in general, to reduce the size of the public sector. In the policy view promoted by major multilateral organizations, such as the International Monetary Fund and the World Bank, *fiscal austerity and privatisations* represent necessary ingredients of a good development strategy, as these may reduce the inefficiency, corruption and other non-market failures related to the functioning of the public system. The neo-liberal ideology adopted in the Washington Consensus, in fact, assumes that market-based competition will lead to a more efficient allocation of resources and, hence, to a better economic

performance in the long run. This type of market-oriented policies, aimed at a reduction of the size of the public sector in developing economies, has frequently been adopted by the IMF and the WB in the form of “structural adjustment programmes”. These have induced many poor countries to implement structural reforms that have strengthened the market system and, correspondingly, have reduced the provision of public services [93].

The drawback of these institutional changes towards a reduction of the size of the public sector, though, is that they have significantly decreased the resources available for fiscal policies, and have thus hampered the possibility to sustain the catching up process through expansionary fiscal policies aimed at the growth of investments and GDP. In times of stagnation, recession and financial crisis, in particular, active fiscal policies may still be important to give a major boost to the economy towards recovery, while fiscal austerity may render the consequences of the recession long lasting and problematic for the development process [17]. The Asian crisis in 1997-98 provides a recent example in this respect, with particular reference to those countries like Thailand and Indonesia that followed the IMF prescriptions and adopted tight fiscal policies and public sector restructuring to overcome the crisis [90].¹⁰

Finally, another relevant aspect strictly related to the Washington Consensus type of policy is the *flexibility of labour markets*. This is certainly an important factor to explain the growth of US, and its rapid adaptation to the new productive system based on ICTs in the 1990s (e.g. [95]). The increased flexibility in labour markets is in fact

¹⁰ In addition to this, lending programmes conceded by multilateral organizations may crowd out public investments and, through this way, they may have a negative effect on long run growth. The recent econometric study of Butkiewicz and Yanikkaia [94] illustrates well this point with reference to the previous empirical literature on the subject, and shows that IMF lending programmes seem to have had a negative effect on long run growth in recent decades, while the evidence relative to World Bank’s programmes is ambiguous and not conclusive.

an important condition favouring structural change and the diffusion of the new technological paradigm, as it makes it possible for skilled workers to rapidly shift from the traditional manufacturing activities where they were previously employed towards the new emerging sectors related to ICTs. However, the shift from the old to the new technological paradigm is a long and lengthy process, which is likely to bring drawbacks, risks and negative consequences in the short-medium run. In developing countries, these risks are likely to be much greater than it is the case for industrialized countries.

One such risks is that a rapid process of structural change requires a fast and significant upgrading of the workers' competencies and skills, otherwise they will find it hard to be employed in the new high-tech industries [39,40]. Labour market flexibility accelerates the process of structural change and, for this reason, increases the possibilities of occurrence of technological unemployment. Relatedly, a possible short-medium term consequence is that in a situation of rapid structural change labour market flexibility may provoke a downward pressure on wages of low-skilled workers [8], and for this reason may decrease consumption and aggregate demand, which are important factors to sustain the catching up process [86]. Thus, the supply-side advantages of a flexible labour market may be counteracted by the disadvantages that the latter leads to on the demand-side of the economy.

As hard as workers have fought for "decent jobs", the IMF has fought for what it euphemistically called "labor market flexibility", which sounds like little more than making the labor market work better but as applied has been simply a code name for lower wages, and less job protection [90, p. 84].

Let us now consider together the important institutional aspects discussed in this section. The progressive liberalization of trade and of worldwide financial capital

movements, the new IPRs system, the pressures towards a reduction of budget deficits and of the size of the public sector, and the tendency towards greater flexibility in labour markets: all of these trends characterize the current international regime, and lead to severe consequences for catching up countries. The major consequence, in a nutshell, is that national governments in developing economies are forced to play a less relevant role in the catching up process, as much of their power is being transferred to MNEs, International Organizations and financial markets.

The Washington Consensus type of policies promoted by these major actors reduce the scope and the resources available for national governments of developing countries to actively sustain the catching up process, constraining in particular industrial policies (protection of infant and emerging industries), monetary and fiscal policies, and national regulations in IPRs related matters. Furthermore, these institutional trends inevitably limit the pool of resources that the State necessitates for promoting innovation-based growth in the new ICT paradigm, thus hampering the implementation of education and training policies, R&D and innovation policies, and investments in the new infrastructures.

4. Concluding remarks

The discussion carried out in the previous sections points to a paradox. On the one hand, changes in the techno-economic system are opening up new windows of opportunity for developing countries, and are increasing the scope for a broad range of public policies to sustain the catching up process (section 2). On the other hand, however, institutional changes are leading to a new international regime where the scope and the resources available for State interventions are significantly reduced

(section 3). This paradox suggests the existence of a *mismatch* between the techno-economic and the socio-institutional system, in a period that marks the initial phase of a fifth long wave period. This mismatch makes the catching up process more difficult for the developing world. The widening of the technology and income gap between rich and poor countries that the world economy has experienced in recent decades is, in our view, a manifestation of this mismatch.

Increasing inequalities and greater divergence between industrialized and developing countries, though, is by no means an obvious prediction for the future of the world economy. On the contrary, the most notable recent successful cases show that a rapid process of innovation- and imitation-based catching up is indeed possible in the fifth long wave. The extraordinary performance of Asian NICs and, more recently, China and India, indicates that it is possible to adopt a development strategy where public policies, also in interaction with market forces, actively foster the development process by investing heavily in the new technologies and in the related infrastructures, capabilities and skills.

The successes show that development and transition are possible; the successes in development are well beyond that which almost anyone imagined a half century ago. The fact that so many of the success cases followed strategies that were markedly different from those of the Washington Consensus is telling [90, p. 88].

Furthermore, taking a longer-term perspective, the neo-Schumpeterian framework that we have adopted in this paper points to the *temporary* nature of the mismatch between the techno-economic and the socio-institutional system. Looking back at what happened in the previous four long wave periods, in fact, neo-Schumpeterian theory indicates that the socio-institutional system has always taken a longer time than the techno-economic to adjust to the emerging technological paradigm. The temporary

mismatch between the two systems has previously been a characterizing feature of the initial phase of long wave periods.

Neo-Schumpeterian theory also points out, though, that once the harmonic complementarity between the two systems is restored, a new mode of development eventually sets in, sustaining growth and catching up for the following decades. What does this long-term perspective suggest about the catching up process in the decades that will characterize the so-called fifth long wave period? The optimistic scenario that this approach leads us to foresee is that after a long period of trial and error, adjustments, social turbulence and political struggle, the international regime will eventually evolve in a direction that will more actively support innovation, diffusion and catching up not only for industrialized countries, but for the developing world as well. When this will happen, the restored complementarity between the techno-economic and the socio-institutional system will favour the emergence of a more equal and more sustainable mode of development.

In this world, the optimists have it, not because they are always right, but because they are positive. Even when wrong, they are positive, and that is the way of achievement, correction, improvement, and success. Educated, eyes-open optimism pays; pessimism can only offer the empty consolation of being right [96, p. 524].

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Table 1: The techno-economic system: windows of opportunity and policy challenges for catching up countries in the fifth long wave

Characteristics of the ICT-based techno-economic system	Windows of opportunities for catching up countries	Policies needed to sustain the catching up process
Information intensive and intangible	Less importance of raw materials and natural resources, greater importance of human skills and knowledge	Education and training policies
	ICT-related infrastructures and communication channels (based on cable and wireless transmission of data) complement the more traditional type of infrastructures	Investments in the new infrastructures and communication channels
	Less commitment to the previous technological paradigm may enable rapid structural change	Training and re-training policies to accelerate structural change, and to avoid the surge of technological unemployment
Flexible production system	Decreasing importance of physical capital accumulation, and increasing role of users' skills and competencies	Improving users' competencies, and sustaining user-producer interactions
The rise of services	The increasing use of ICTs in services make standardisation less important, and leads to greater customisation over time	
	The limited appropriability of innovation in services may increase the scope for knowledge diffusion within services and to manufacturing industries (the "efficiency" effect)	Incentives to innovation, R&D and entrepreneurship; IPRs regulations
	Non-technological and organizational types of knowledge are increasingly important for the diffusion of advanced knowledge ("expertise field innovation", consultancies and KIBS)	Sustaining education and training in non-technical fields to promote knowledge diffusion
The "network-firm"	Increased speed of knowledge diffusion, and rapid access to new and wider sources of information	Large firms (MNEs) may exploit economies of scales in global production and distribution networks: competition and regulation policies are important to enhance market efficiency
E-commerce	Changes in the distribution chain may favour the commercialisation of products produced in peripheral regions of the world economy	
Globalisation of technological activities	The international exploitation of technologies, the global generation of innovations by MNEs, and techno-scientific collaborations may favour the international diffusion of advanced knowledge	Industrial policies to sustain foreign competitiveness of high-tech sectors; Policies to upgrade domestic capabilities, skills and infrastructures, which may increase the benefits related to the new forms of competition and collaboration in global markets