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Catching Up: in different sectoral systems.

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Catching up in different sectoral systems.

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1. Introduction

This paper aims to discuss factors affecting catch-up in six different sectoral systems - autos, telecommunications, pharmaceuticals, software, semiconductor, agro-food - in several different countries - China, India, Brazil, Korea, Taiwan and others. The research presented here is part of a larger program of studies concerned with the examination of various aspects of the phenomenon of catch-up in economic development, from the role of domestic capabilities of firms, to the differences existing across sectors, to the measurement of catch-up, to the effects of IPR, and so on.

The paper is organized as follows. In section 2 we will discuss the basic orientation of the broad “catch-up program”. In section 3 we argue for the importance of analysis at a sectoral level, because there are significant differences across economic sectors in the variables and mechanisms involved in catch-up. This section identifies the main sectoral variables used in the following analysis. Sections 4, 5, and 6 discuss the development of the sectoral systems analyzed in the study, the factors that are common, those that differ across the different sectors, and the relevance of national differences that hold across the sectors.

2. Economic development, catch-up and innovation systems

In the following pages we briefly recall the major broad starting points raised by the “catch-up program” (see Nelson et al, 2005 for a more in depth discussion). Economic development involves deliberate efforts to “catch-up”, in the sense that economic and technological practice in leading nations is used as a model. Catch-up however does not mean cloning. What actually is achieved invariably diverges in certain ways from practice in the countries serving as the model. In part this divergence reflects the fact that exact copying is almost impossible, and that attempts to replicate at

best get viably close. In part it reflects modifications required to tailor practice to local circumstances. The organizational, managerial, and institutional aspects of productive practices often are the most difficult to replicate, and the most in need of adaptation to indigenous conditions, norms, and values. So, each developing countries does things in a different way, as a result of an indigenous process of learning

The development process involves innovation in a sense of Schumpeter, as a break from traditional ways of doing things. This break however does not concern only technologies. As Schumpeter emphasized, in many cases innovation involves the establishment of a new mode of organizing work, or a new management practice. Innovation can involve the entering of a new market or the tapping of a new source of supply. In the process of catch-up the practices being brought in are certainly not new to the world, but they are new to the country, and bringing them in involves considerable risk, and requires a lot of trial and error learning to be effective.

The learning of new capabilities by firms is of central importance in almost all economic sectors. In catching up many different kinds of capabilities need to be acquired. These capabilities involve a lot more than what engineers generally mean when they talk about technology. While important aspects of these activities are indeed structured or embodied in machinery or other physical artifacts, they also involve modes of organizing, coordinating, and managing activities. These latter capabilities often are much more difficult to develop than the needed engineering know-how. Thus various capabilities are needed for catch-up: capabilities to access complementary assets, absorptive capabilities and innovation capabilities. All these capabilities are required in order to adopt, adapt and modify technologies developed elsewhere, introduce modifications and incremental innovations and eventually generate totally new products and processes.

But firms do not act alone. They must be understood as operating in the context of innovation systems that includes other kinds of economic actors that are involved in supporting and orienting the dynamics of economic activity and innovation: financial systems, primary and secondary education, universities, the public research system and government programs (Nelson,2006). The structure of the financial system is also pivotal. Since the catch-up process involves a significant shifting of resources away from old firms and industries, the financial system must enable this transfer.

And in the present era, the education system is also of vital importance. Over the last century, all the countries that have been successful in catching up have had a system of primary and secondary education that endowed a large fraction of the young population with the basic skills needed to operate in a modern technology, and also provided high level training for a sufficient group of scientists and engineers to enable foreign technologies to be absorbed. The fact that today so much of technology is a science based means that a country's system of advanced training in science, technology, and the other bodies of knowledge needed to master modern ways of doing things, is quite important. And research at universities and public laboratories has increasingly played a central role. Public sector research long has been an important element of catch-up in certain fields. This is certainly so in agriculture, and medicine, where developing countries often could not simply copy technology and practice in countries at the frontier, but needed to develop technologies suited to their own conditions, because soil and climate conditions and the prevalent diseases tend to be different.

Also active government policies have supported the catch-up process, involving various forms of protection and direct and indirect subsidy (as the cases of Japan, and of Korea and Taiwan illustrate). In many countries however these policies engendered not successful catch-up but a protected inefficient home industry.

Finally also institutions shape firms actions: the labor market, the education system, financial institutions, regulatory structures, and other institutions that shape economic dynamics more broadly.

3. Catch-up and sectoral systems

This project studies catch-up in six different sectors - telecommunications, software, pharmaceuticals, automobiles, semiconductors and agro-food – in several different countries. The basic starting point of the sectoral project is that a sectoral orientation is illuminating because there are significant differences across economic sectors in some of the key variables and mechanisms involved in catch-up.

Of course, there are certain common elements across different sectors, along the lines discussed above. Development involves using practice in leading countries as a model or target. The bringing in of new practice is innovation, with all the associated uncertainties, risks of failure and need for learning. And what is achieved in catching up almost always has elements specific to particular countries.

But firms operate in the context of broader sectoral innovation systems that differ from sector to sector. Here the notion of sectoral system (Malerba, 2002) is going to be helpful for the sectoral analysis. In the following pages the main constituent dimensions of a sectoral system and their relevance for catch-up are discussed in an introductory way.

a. Key actors

In any sector, *firms* are the key actors in catch-up. This confirms what other authors have pointed out forcefully in the literature on development. Kim (1997) has identified different stages of capability development, from duplicative imitation to creative imitation to innovation. Amsden and Chu (2003) have examined the combination of production engineering and design by large scale enterprises in electronics in Taiwan. Lee (2005) has discussed the passage from the creation of absorptive capabilities to the development of complementary assets (complementary to the ones of firms in advanced countries). Lee and Lim (2001) have focussed on different trajectories of catching up, from path following to stage skipping, to path creating. Mathews (2002) and Lee (2005) have discussed different steps that firms have followed in the process, from OEM to ODM to OBM for Taiwan, and from OEM to OBM for Korea. Several authors have discussed the process of capabilities accumulation from learning from FDI as an initial channel, to licensing, to indigenous R&D (for example, Amsden and Chu, 2003 for electronics). This last process, as Lee (1995) has pointed out, has to be supported in various ways: production and R&D consortia and joint-ventures, scouting and foreign alliances and support from government research institutes. In this paper we claim that firms' specific learning processes, competences and organizations, as well as beliefs, expectations, and goals, are highly affected by the specific sectoral system they are in.

Other actors that are relevant in a sector system but that may differ in their extent, role and competences across different sectors are :

- *Users, customers, the sources of demand*
- *Upstream suppliers;*
- *Universities and public laboratories;*
- *Financial organizations;*
- *The public sector;*

In the catch-up process *interactions among actors*, that is *networks*, play an important role. Relationships among actors are important because most of the actors discussed above are connected in various ways through market and non-market relationships and through formal and informal interactions. Often these networks provide access to, and allow for the integration of, complementarities in knowledge, capabilities, and specialization (see Lundvall,1993; Edquist 1997;). Relationships between firms and non-firm organizations (such as universities and public research centres) have been a source of innovation and change, but have differed across sectoral systems (Nelson-Rosenberg,1993).

b. The Knowledge base

Different sectors are characterised by different knowledge bases. One important part of sectoral knowledge is the scientific and technological fields at the base of innovative activities in a sector (Dosi, 1988; Nelson and Rosenberg,1993). Another important part relates to applications. The latter is especially important to users, but producers and innovators need to know how their products are used. The sources of technological opportunities markedly differ among sectors. As Freeman (1982) and Rosenberg (1982), among others, have shown, in some sectors opportunity conditions are related to major scientific breakthroughs in universities. In other sectors, opportunities to innovate may often come from R&D done by firms in the industry directed to the design of new products and production processes. New forms of equipment and instrumentation created by firms outside the industry may facilitate innovation by firms in the industry.

In general, the features and sources of knowledge in a sectoral system affect the learning processes and the relevant capabilities of firms, the rate and direction of technological change, the organization of innovative and production activities, and the factors at the base of firms' successful performance in that sector.

c. Institutions.

Agents' cognition, actions and interactions are shaped by institutions, which include laws, rules standards, norms, routines, common habits, established practices, and so on. And institutions may range from ones that bind or impose enforcements on agents to ones that are created by the interaction among agents (such as contracts); from more binding to less binding; from formal to informal (such as patent laws or specific regulations vs. traditions and conventions). While some institutions are national (such as the patent system), others are specific to sectors (such as sectoral labor markets or sector specific financial institutions). And even national institutions *can* have different effects on sectors. For example, the patent system and IPR may have different effects on different sectors. In a similar vein the same nominal institution may take different features in different countries, and thus may affect the same sector differently in different countries.

Often the characteristics of national institutions favor specific sectors that fit better the specificities of the national institutions. And in certain cases some sectoral systems become predominant in a country because the existing institutions of that country provide an environment more suitable for certain types of sectors and not for others. However, sometimes the direction of causality goes from the sectoral to the national level. In fact, it may occur that the institutions of a sector, which are extremely important for a country in terms of employment, competitiveness, or strategic relevance, end up emerging as national, thus becoming relevant for other sectors. But in the process of becoming national, they may change some of their original distinctive features.

d. Government programs and policies

As mentioned in Section 2, government policies and programs have been quite important in several cases of catch-up. They have often been targeted to specific sectors: In this part we will just mention only some work that have emphasized the key role of the government. For example, these have been the cases of semiconductors and computer hardware in Japan (Goto and Odagiri, 1993), Korea (Kim1997, Lee and Lim,2001) and Taiwan (Mathews, 2002, Amsden and Chu, 2003 Hobday,1995); software (Arora and Gambardella, 2005) and aircraft in Brazil (Dahlman and Frischtak 1993 and Viotti 2002).

e The particular dynamic processes involved in catch-up

Catch-up is inherently a dynamic process. Because sectors differ and the elements of a sectoral system are more or less closely connected, it follows that their change over time often results in sector specific co-evolutionary processes. This process of sectoral catching-up involves the actors, knowledge base and institutions of the sector, and the operative government policies and programs. (as Nelson(1994) and Metcalfe (1998) have discussed in a broad way).

As a way of conclusion of this part on the key variables of a sectoral system, one could briefly recall that there is a major conceptual difference between a sectoral system and a national system perspective. While national innovation systems take innovation systems as delimited more or less clearly by national boundaries, a sectoral system approach would claim the boundaries of the innovations process in sectors may have local, national, and/or global dimensions. Actually often these three different dimensions coexist in a sector, because the different variables may have different geographical boundaries. This is a very important point for the study of catch-up, because often a country catches up in a sector within a well defined intra-sectoral division of labor and global value chain.

4. Catch-up in six sectoral systems: the sectors and the similarities across them

4.a The six sectors examined

The six sectors examined in this project are pharmaceuticals, autos, software, telecommunications, agro-food and semiconductors – PASTAS -. They represent a wide range of sectors according to various classifications. The set includes a science based sector – pharmaceuticals -, sectors where product design and engineering is important - semiconductors and telecom -, scale intensive ones - such as auto, specialized supplier and service sectors such as software, traditional sectors such as agro-food. All these sectors have a high rate of change, but the sources of change are quite different, ranging from advances in scientific knowledge, to firm R&D, to external sources such as universities and so on.

Also the countries examined are quite varied: China, India, Korea, Taiwan, Brazil, Nigeria, Taiwan, Costa Rica, Malaysia and others. They range from countries which started their catching up quite early such as Korea and Taiwan, to countries which are now becoming major protagonist of economic development such as China and India. Also these countries differ very much in terms of the size of the domestic market. In some of these countries (such as China, India and Brazil) the size of the domestic market has been a major target for firms. In others, the internal market is small.

The sectors examined in this paper have often been major drivers of economic growth of a country. This is the case of automobiles, pharmaceuticals and telecommunications, for a number of reasons: the employment that these sectors generate, the amount of capital investments and the knowledge spillovers that have affected other sectors. Other reasons refer to the vertical linkages that these

sectors have within a country : telecommunications and software, agriculture and the food industry, semiconductors and machine tools or computers. These types of effects of the *filere* type have proved very relevant for countries such as China (telecom and software, agriculture and food industry), Malaysia (semiconductor and machine tools) and Taiwan (semiconductors and computers)

4.b. Some common factors affecting catch-up in all sectors

The studies of the six sectors are still in process. As far as preliminary results are concerned, some factors that are common to all the sectors have been identified.

- Learning and the formation of capabilities of domestic firms

The main factor at the base of catch-up seems to be *the learning and capabilities of domestic firms*.

This confirms what previous studies have found.

An additional point that emerges from the six sectors examined is that *the stages* of capability building have followed a similar pattern. The first stage of capability building for the production of modern products or processes can be associated with the beginning of exports or sales on the domestic market or both. The leading firms at this early stage may be indigenous, or they may be a local branch of a multinational. For indigenous firms, access to foreign knowledge and links with multinational are not substitute to internal learning but are complementary to it. Their role consists in the feeding the learning process of domestic firms with key knowledge, technologies and know-how. Often this initial stage is characterized by subcontracting and low cost production in an international division of labour or by specialization in low end products, which are then exported to international markets. For larger countries such as China, India or Brazil, the production for the domestic market of low end products and at low price has been quite common in this stage. These

are the cases of generics products in pharmaceuticals, software business services and business process outsourcing, and back-end processes in semiconductors. Governments have been quite active in this stage, in various ways.

With time, the process of learning and capability formation is characterized by a change in the relationship between the domestic firms and foreign firms, in the products offered, in the type of specialization and in exporting. The relationship of domestic firms with multinational companies becomes more one of an equal base, and involves the creation of partnerships and joint-ventures. Production and specialization upgrade from subcontracting and low-end products to more innovative, higher hand products. Innovation here is not of the radical type. Rather, it is an adaptation or incremental change of existing products. Exports increase.

The ongoing sectoral studies have also proposed some cases in which *different trajectories of capability development across countries* are present *for the same sector*. The variety of trajectories seems due to several factors: the knowledge base of a sector may provide room for heterogeneity in capabilities and behaviours; different technologies and product niches may allow for different within sector specialization; the different size of countries has an effect on the choice between exporting or focussing on the local market; some key unique actor (such as a large firm) maybe present in a country; finally some “historical accidents” may start a specific path dependent process of catch-up.

Software provides a good example. In software, the key role of firms learning and capabilities, dynamic entrepreneurship and abundant supply of advanced labour skills which has been present in all the stages of catching up has been accompanied by different country specialization, and by different patterns in the three waves of catch-up that this sectors has experienced (Niosi et al).

India focussed on software services, Israel on high-tech software products and Ireland on products

for the European market. Similarly, differences emerged with respect to outsourcing and participation to the global value chain in vertical software applications, usually coordinated by final software suppliers. Differences have also emerged with respect to the size of the domestic market, which has been large for China and Brazil and which represented a clear target for the activities of domestic firms. Smaller countries such as Ireland and Israel have focussed on the other hand on exports. In these two countries the role of foreign subsidiaries of multinational corporations played a major, but differentiated role: doing R&D in Israel and tapping into the European market in Ireland.

- *Access to foreign knowledge and international networking.*

A second factor common to all cases of successful catch-up has been access to foreign knowledge. However the channels to which this access took place have differed from country to country and from sector to sector. Most of the time access meant effective networking. And networking could be of various types – from vertical networks with suppliers and users, to local networks, collaborative R&D or production agreements, to participation to the global value chain or just outsourcing -. When access to foreign knowledge did not take place, as in telecommunications in India and Brazil, the catch-up process has been seriously unpaired (Mani et al)

- *The development of advanced human capital*

A third common factor has been the development of advanced human capital. This factor proved particularly relevant in sectors highly dependent on skilled labor, entrepreneurship and the creation of new firms. The cases of the catching up in software (Niosi et al) and of India in pharmaceuticals (Ramani et al) are very good examples.

Related to that, the international mobility of skilled labour from advanced countries has been key for countries such as India, China and Taiwan in sectors such as software, semiconductors and pharmaceuticals.

- *Government policy*

In our six sectors government policy has indeed stimulated and fostered the learning processes and the capability formation of domestic firms.

5. Differences across sectors

The sectoral studies in the making have highlighted a variety of factors that have differed significantly across sectors. They are related to the type of industry structure, to the role of multinationals, networking, demand, university and public research laboratories, finance, government policies, regulation and standards, and to co-evolutionary processes. These factors are discussed in the following pages.

- *Industry structure*

Industry structure has varied considerably across sectors. In automobile and telecom large firms have been major actors in the catch-up process (Hyun et al). On the contrary, in software and agro-food small firms have driven sectoral growth. When successful, some of these firms have grown to medium or even large size. (Niosi et al; Gu et al). New entrepreneurial firms, some of which are of small size and some of medium or large size, characterize the pharmaceutical and the semiconductor firm (Rasiah et al; Ramani et al). In addition, local networks have been quite important for the catch-up process in sectors such as semiconductors. For example, in the Taiwanese electronic industry industrial districts have played a key role in the development of the

sector. These local networks have allowed intense formal and informal interaction, knowledge sharing and intense division of labor. (Rasiah et al).

Depending on the sector, the advent of technological and market discontinuities may favour either totally newcomers or established domestic companies. In software often discontinuities in terms of markets and applications have favoured the entry of new firms. On the other hand, if knowledge in the sector is cumulative (such as in telecom), or strongly based on scientific knowledge (such as in pharmaceuticals), a technological and market discontinuity such as mobile phones or biotechnology favours the firms that in the catching up countries have already accumulated a broad set of competences rather than completely new actors with completely new competences. (Lee et al, Ramani et al) The case of telecommunications in countries such as India, China, Korea and Brazil is a good example. In this sector catch-up has been possible when domestic firms have been able to learn and accumulate advanced technological capabilities through internal R&D and through learning from cooperation and access to foreign sources of knowledge. Korean and Chinese firms have been particularly successful in doing that, and Brazilian and Indian much less so. When there as been the technological discontinuity from fixed to mobile telecom to broadband technology, Korean and Chinese firms, and not Brazilian and Indian firms, were able to jump successfully on the new technology (Mani et al).

- *Multinationals*

An intriguing issue regards the different role played by *multinational corporations* in different sectors and in different countries. In sectors such as software, pharmaceuticals and semiconductors, multinational corporations globally governed the innovation process and established global value chains in which international production was outsourced. In this realm, catching up countries had to specialize in some product range due to their specific advantages in terms of labour costs, skills or location. Successful firms eventually were able to learn within a specific stage of research or

production, and eventually move up the learning ladder to more advanced stages of production or research. In other sectors, such as telecom and auto, the use of license from multinationals or from foreign firms, or joint ventures and alliances have been extensively used by domestic firms to learn and accumulate capabilities. Finally, in some cases competent local branches of multinational corporations have been quite active. This is the case of auto in Brazil. Here international producers developed strong capabilities in production at their local branches, activated a set of local suppliers of parts and produced cars targeted to the local market (Huyn et al.).

- Demand

Demand has entered catch-up in two ways: exports and the domestic market. In most cases, exports have been the drivers of catch-up, for both small firms and large firms. This is the case of semiconductors, telecom, pharmaceuticals, software and auto. In addition to exports, for large countries such as China, India and Brazil a large domestic market has been a major driver of the learning process and the accumulation of capability by domestic firms. Of course, the growth of domestic demand has gone hand in hand with the growth in income per capita. However, sometimes the type of products offered to the domestic market by local firms has been different from the products and production done for exports within the international division of labor- see for example the case of pharmaceuticals for the Chinese and Indian markets- . This has indeed favoured domestic production (Ramani et al). A similar case is the one of a segmented domestic market which has different features compared to the international market (and which has been protected): this has been the case of segmented markets in telecom in China (Mani et al). Finally, in some sectors the growth of the domestic market stimulated the growth of exports, which in turn had a positive effect on the improvements of products for the domestic market. This has been the case of vegetables in China. In the case of coffee in Costa Rica, the dynamic relationship went the other way: exports started first, and were later on accompanied by the rise of a domestic demand for coffee, which in turn fed back to exports (Gu et al.).

- *Channels of networking.*

As far as *networks* are concerned, in some sectoral systems, such as semiconductors and software, vertical networks with suppliers have provided new inputs, been a source of complementary knowledge, shared relevant information for production and innovation, and led to learning and capability development by domestic firms (Rasiah et al., Niosi et al.). In other sectoral systems, such as telecommunications and auto, catch-up has been characterized by collaborative agreements in production and R&D among domestic firms and foreign firms, and sometimes only among domestic firms, so that complementary knowledge and capabilities could be shared over the medium run. This has been the cases of Korea and China (Mani et al, Hyun et al). Finally, in software, semiconductors and agro-food specialization in different stages of the global value chain has been another way to get access to foreign knowledge and international market and then, with the development of domestic capabilities, to upgrading within the value chain. (Gu et al; Rasiah et al, Niosi et al). This last channel and process has been common also to other cases regarding the global value chain – regarding ICT, medical instruments, textiles, clothing and footwear and furniture - (Gereffi 2005, Ernst, 2002, Lee, 2005, Morrison, Pietrobelli and Rabellotti, 2006).

- *Universities and public research laboratories*

In some sectors *universities and public research laboratories* have played a role in catch-up. This is due to two mechanisms. First of all universities and higher education institutions have provide advanced training for advanced human capital in the scientific, engineering and managerial fields. Second, universities and advanced research laboratories have conducted research in scientific and technological areas that proved quite relevant for domestic firms (Mazzoleni and Nelson,2006). In agriculture, in Korea and Taiwan experimental stations had a pragmatic orientation and a focus on user needs (Hayami and Ruttan, 1985). In telecommunications in Korea and Taiwan universities formed advanced human capital and large public research laboratories did advanced research and

collaborations with domestic firms - such as the Korean KIET/ ETRI and the Taiwanese III/ITRI/ERSO - (Mani et al; Mazzoleni and Nelson, 2006). Also in pharmaceuticals in India universities have conducted significant research which proved useful for domestic firms (Ramani et al).

- *Finance*

Finance has played a particularly relevant role in those sectors in which entrepreneurship needed resources to fund new ventures. This has been the case for software and pharmaceuticals. Here new financial actors such as venture capital companies have been important (Niosi et al; Ramani et al,)

- *Types of government policy.*

Government policy has differed in the use of tools and measures - R&D support, fostering competition, protection of domestic firms, policies of benign neglect, creation of advanced government research institutes, support for entrepreneurship-. In telecom in some countries - such as Korea and China - public policy used R&D support, R&D consortia and public research organizations and was able to successfully support and coordinate firms' domestic efforts and to help firms to move into new generations of telecom technologies and products. On the contrary Brazil and India had a less direct and coordinated intervention and public policy was less successful in actively fostering the direction of change in the domestic industry (Mani et al). In software governments have used different policies and tools, ranging from procurement, to R&D support, favourable companies tax rates and incentives to attract foreign direct investments (Niosi et al)

- *Standards regulations and norms*

Standards, regulations and norms have been important in fostering or in blocking catch-up in various sectors. Software represents a good example of the positive role of institutions in catching up (Niosi et al; Arora and Gambardella, 2005). And the health systems of China and India have

affected in specific ways the supply of generics and new drugs by domestic firms targeted to the domestic market (Ramani et al,)

- *Systemic and dynamic relationship among factors*

Finally, systemic and dynamic relationships among factors relevant in a sectoral system have differed from sector to sectors. In fact, in a system approach, the variables composing a sectoral system and examined above do not work in isolation. Rather, they are link through some complementary relationships. Often one factor alone cannot trigger catch-up unless other factors are present, and they feedback on each other. In general, from the six sector examined one key complementarity which proved necessary for catch-up has been the one between the development of capabilities by firms, the formation of human capital and the access to foreign knowledge through networking. Learning and capability development has been possible by the presence of a skilled and advanced labour force which represented the backbone of learning and fostered the absorption of key knowledge developed by companies in countries at the frontier. This key general complementarity has been present in all sectors and all countries that successfully caught up.

However, from research in progress on the six sector specific complementarities seem to have been at work in the various sectors. In software, relationships between on the one hand capability development, human capital formation and access to foreign knowledge, and on the other a vibrant entrepreneurship (in terms of small and medium size firms) and link with foreign customers (be final customers or intermediate customers represented by multinational corporations) have been present (Niosi et al). In telecom, links between on the one hand capability development, human capital formation and access to foreign knowledge and on the other large firms, public research institutes and quite active government policies have been quite relevant (Mani et al). In semiconductors, links between on the one hand capability development, human capital formation

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and access to foreign knowledge and on the other entry of new firms and major specialization in the international division of labour have been significant.. (Rasiah et al). Finally, in pharmaceuticals links between on the one hand capability development, human capital formation and access to foreign knowledge and on the other research at universities have been important (Ramani et al).

And in a dynamic setting, the timing of catch-up is very important. Often catch-up has taken place in the mature stage of industry life cycle (as in automobile and semiconductors). In other cases, technological discontinuities have provided a new spur to catch-up (as in the case of the switch to mobile phones in telecommunications)

6. The effects of national innovation systems across different sectors

Research on the six sectors is providing evidence on the effects of national innovation systems on various sectors. It is still early to come to some definite conclusions. However it seems that this effect has been particularly true for some variables: industry structure, the type of access to foreign knowledge, the relationships with multinationals, and government policy. For example, the Korean national innovation system characterized by large firms, extensive uses of licences from multinational corporations and a very active government policy (protecting the domestic market while supporting the R&D and capability development of domestic firms) has affected all sectoral systems in that country and has proved particularly effective in the catch-up in auto, telecom and semiconductors. On the contrary the national innovation system of India characterized by vibrant entrepreneurship and small and medium size firms (in addition to large firms), by the active presence of several multinationals in the country and by a less interventionist government policy has had a similar effect on a different group of sectoral systems, such as software and pharmaceuticals.

A related question stemming from the previous issue is whether some countries fit some sectors better than others. To put it differently, do the industry structure, institutions and policies that characterize a national innovation system fit better some sectoral systems than others? To remain to the examples of Korea and India, is Korea doomed to success in the catch-up of all the sectors that resemble automobile, telecom and semiconductors – i.e. all sectors characterized by large firms and government intervention or protection- and doomed to failure in all the sectors that resemble software and services – i.e. characterized by small entrepreneurial firms and a less relevant role of active public policy –? And is India doomed to success in sectors that resemble software and doomed to failure in sectors that resemble telecom and semiconductors?

6. Conclusions

We hope to have illustrated the basic conceptual framework and the first preliminary results of the current research on catch-up in six sectoral systems. We are convinced that once concluded, this research will shed light on the different factors that affect catch-up in different sectors and to the interplay between national factors and sectoral systems in the process of economic development.

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