NATIONAL INNOVATION SYSTEMS AND ECONOMIC CATCH UP: LESSONS FROM RECENT EXPERIENCES

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ABSTRACT

The last twenty years showed dramatic change in the working of Innovation systems of low and middle-income countries. In Europe newcomers has known an impressive catch up process, which leads to a convergence process inside the EU, with important differences in the National Innovations systems. Eastern Asian countries, mainly Korea and Taiwan, experienced an even more impressive catch up process, which allows them to reach the group of High-income countries. On the contrary, other middle-income countries remains blocked in a "middle-income trap". The success of the strategy of the former countries lies in their ability to develop short cycle technologies, which enable them to create and localize their own knowledge base. Another way to improve the efficiency of the Innovation Systems of emerging countries is to promote user innovation, which will bend technology to the satisfaction of their needs. That requires the development of technological and social capabilities that will allow these countries to upgrade their innovation performance.

Keywords: Economics of innovation, Economics of knowledge, Technological Diffusion, Convergence and catch-up process.

JEL Code: O140 O47

1. Introduction

Eastern and Southern Europe Emerging Economies, including Turkey and Maghreb countries, have experienced recently a catch up process towards more advanced economies, mainly grounded on the adoption and adaptation of prevailing techniques used in these economies. From this point of view the European Union experience, with its progressive enlargement to Southern, then Central and Eastern gives an insightful experience field. The technological catch up process that occurs during last 20 years has been widely documented in the different European Innovation Surveys (CIS1 to 4) and in the European Innovation Scoreboard (Innometrics, 2011). They showed how the latecomers in the European Union increased they Innovation Performance with low investment in R&D and more generally in Knowledge industries. Now other countries outside the Europeans Union are following the same way.

During the same period, emerging Asians countries knows a parallel impressive catch process, especially South Korea (Lee, 2013), in developing their manufacturing capacities. More precisely, these countries succeeded by implementing industrial policies that allows them to upgrade their competitivity from low to middle, then upper middle and even high income countries in a relatively short period. On the contrary, other developing countries,

after beginning their catch up process in joining the group of the middle income countries group, failed to continue this process and know a stagnation of their GDP growth, falling down into the « middle income trap » (Lee, 2013). This trap lies in their specialization in low technological level industries, and in their inability to upgrade their specialization in more advanced technologies.

The aim of this paper is to address this issue from the point of view of Eastern and Southern Europe emerging economies. These economies are at a crossroad, with new opportunities coming from the proximity of the most advanced European countries, but also with the risk of falling down in the "Middle-Income Trap". From a general standpoint they should develop and promote their own National Innovation Systems, as they already did it. But as this paper will try to prove, they should take account of two specific points that will interfere with their policy design.

First, lessons have to be taken from the experience of the former catch up countries, in designing their industrial policy (Lee, 2013). This industrial policy has promoted short cycle technologies that allow them to improve dramatically their international specialization in a short time. The adoption of these technologies is crucially linked to the accessibility of these countries to a foreign knowledge base, and of their ability to appropriate it.

A second important point is linked to the development of User Innovation, or Innovation by users (Gault and Von Hippel, 2009) that is a major source of Innovation Product and Process. As the process of technological diffusion is becoming more complex, it concerns not only its producers, but also its users (Von Hippel, 2005). That means innovation process needs to promote innovation users, who have the ability to modify an existing product or process, or to create a new use for it. This kind of innovation has been encouraged by the development of the Information and communication technologies, the most prominent example of this development being the experience of Free Open Source Software (FOSS), in advanced like in developing countries. While this kind of innovation appeared for a first time in the more advanced countries, it is a challenge that the middle-income countries will have to cope with. It is an important way to appropriate new technologies that these countries should promote, in order to adapt technologies. Promoting them is an important stake, as they will help to promote adapted technologies and leapfrogging innovation strategy.

The paper will in a first step present the European Experience in the field of Innovation, and detail the catch-up process that has been experienced over the last Twenty years, and the different factors that influenced it. In a second point, a comparison will be made with the experience of other catch-up process, more precisely of other middle-income countries, from South America and East Asia. The question of the "Middle-income trap" and of the way to escape it will be discussed. Lastly the issue of the development of Innovation users will be addressed.

2. The dynamics of Innovation and Technological catch up: some recent results

Countries from Eastern and Southern Europe has recently known a catch up process, that let them become upper middle- and for some high-income countries, but with different performances of their national Innovation systems.

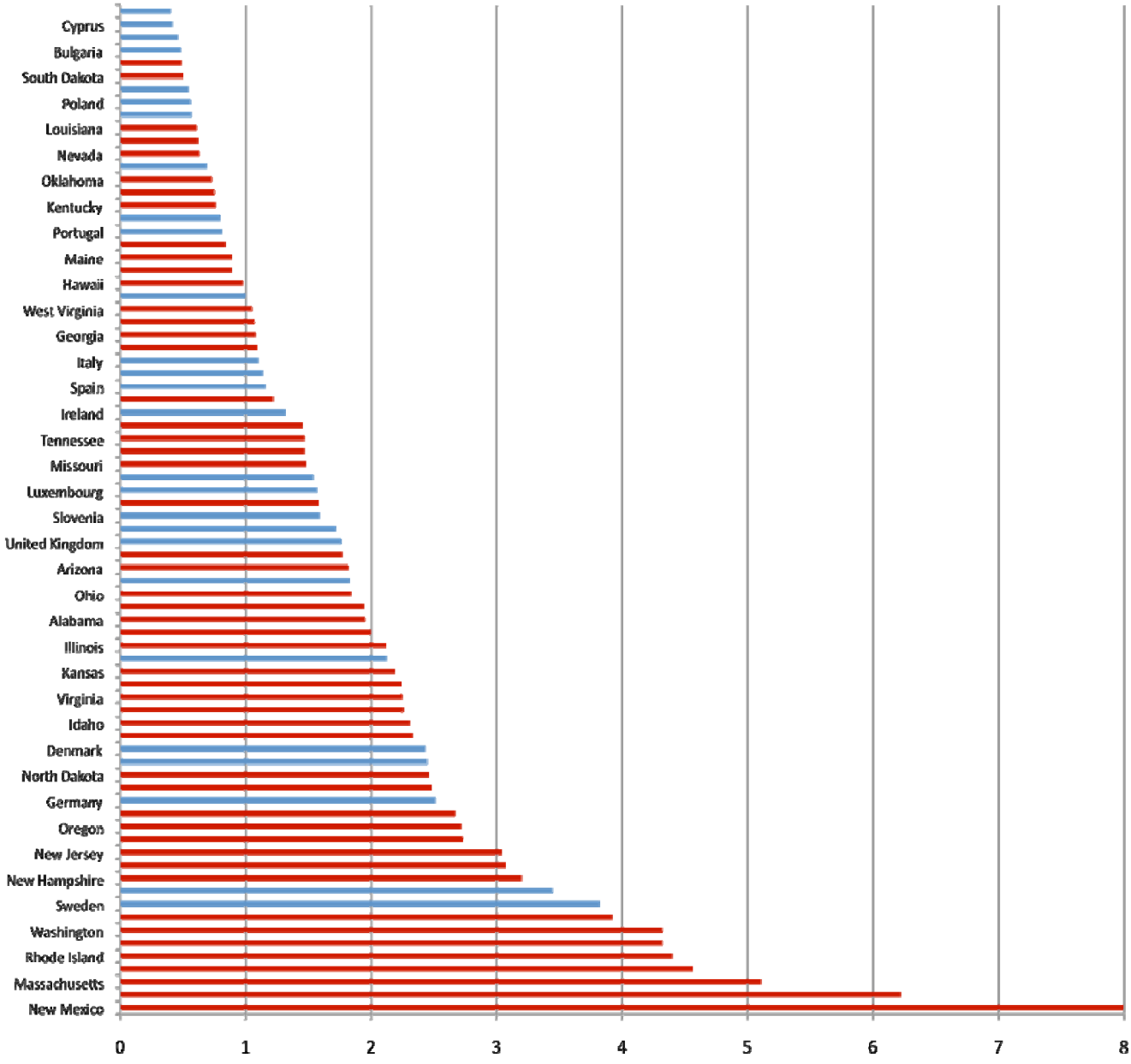
2.1 The European Experience: a fast convergence process, with large disparities in Innovation performance

Over the past thirty years the European Union experienced an exceptional historical convergence process which concerned at first the Southern European countries, and after the Central and Oriental European countries. From this point of view the Lisboa Strategy aiming a ratio of 3% of the GDP devoted to R&D by 2010 was doomed to fail since the first millennium decade saw the integration of low RD level countries, lower than 0,5% of their GDP, which exert a negative effect on the aggregated data.

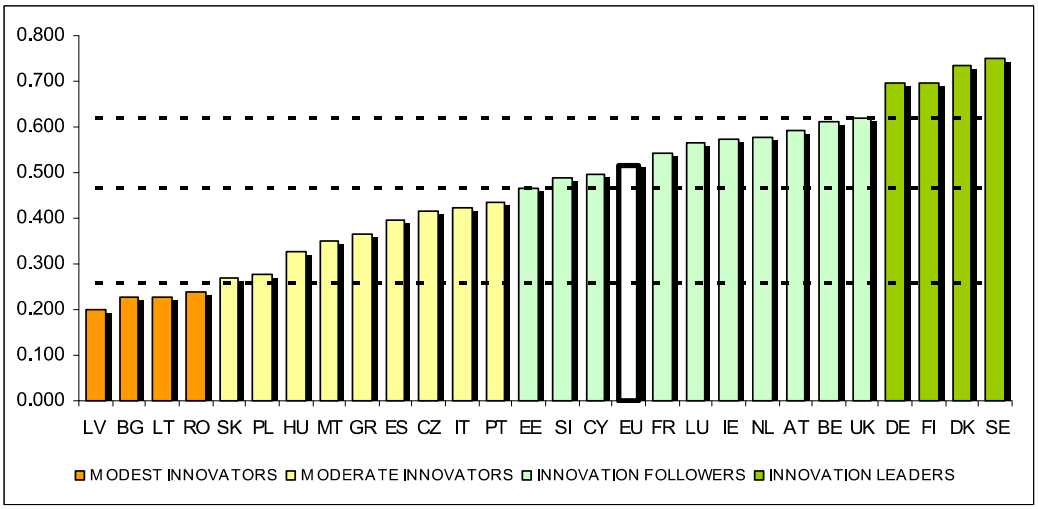
Comparing Europe to more homogeneous countries like Japan or USA is, from this point of view, nonsensical. The alleged R&D gap is decreasing when the European States performance in this field is detailed. It has been done by Van Pottelsberghe, who compared the R&D performance between the European and the American Federal states: if some "high tech" American federal states obtained far better result than the European ones, the ranking between the two geographical areas is quite mixed, for example the Scandinavian countries appear in the top group of this ranking. (Van Pottelsberghe, 2008). On the contrary, latecomers in the European Union, which shows very low level of R&D spending, are close in this field to some rural

The large disparities between European countries innovation performance are confirmed by the four CIS studies over the last ten years, and the European Innovation Scoreboard, now Innovation Union Scoreboard (IUS, Innometrics, 2011, see box 1). This Scoreboard ranks the European countries according to an index of Innovation Performance, build up from 29 indicators, in four main categories: innovation enablers, firm activities and innovation output, lead to a clustering in four groups, namely the innovation leaders, (dark green), the innovation followers (light green), the moderate innovators (yellow) and the modest innovators (previously catch up countries, orange). As it could be guess, this ranking is close, but not similar to that of R&D intensity. For example, Germany, with a R&D intensity close to that of France, belongs to the group of Innovation leaders, while France appears in a lower position in the innovation follower group. On the bottom of the innovation performance index it can be seen that some newcomers in the Europe Union are ranked in a better position that their R&D intensity let guess.

Figure 1 R&D intensity of US Federal States (2004) and EU Members States (2006)



Source: Van Pottelberghe, 2008

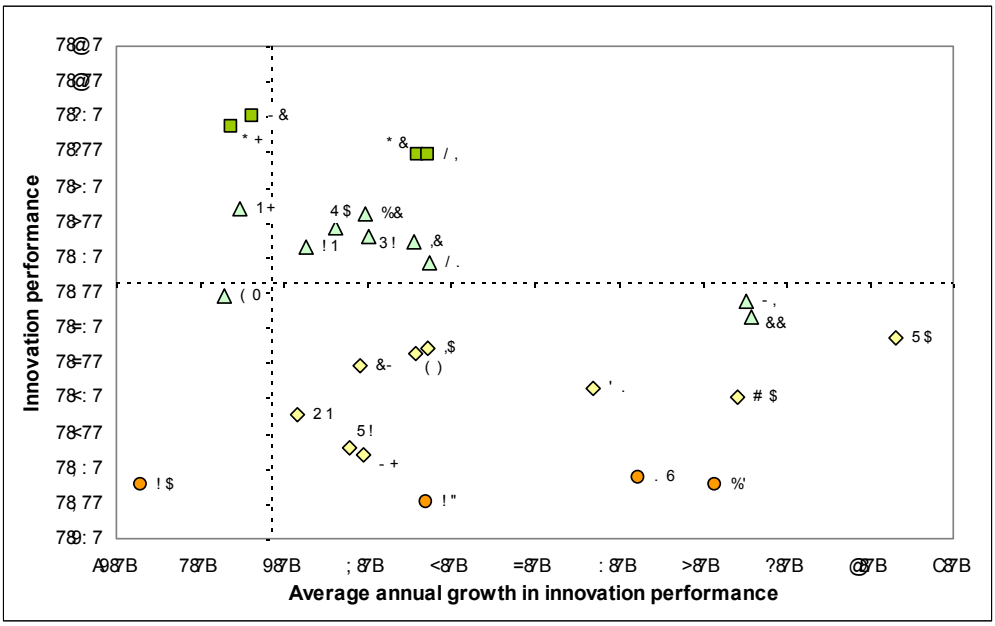


Note: Average performance is measured using a composite indicator building on data for 24 indicators going from a lowest possible performance of 0 to a maximum possible performance of 1. Average performance in 2010 reflects performance in 2008/2009 due to a lag in data availability.

The performance of Innovation leaders is 20% or more above that of the EU27; of Innovation followers it is less than 20% above but more than 10% below that of the EU27; of Moderate innovators it is less than 10% below but more than 50% below that of the EU27; and for Modest innovators it is below 50% that of the EU27.

Figure 2 EU Member States Innovation PeSourrformance

As one can check on the following figure, which plots the growth rate and level of each country innovation performance, a convergence process is in progress: level and growth rate are inversely related, with important divergences between countries in each group. For each category we can find countries with slow, moderate or fast growth. It is worthwhile to note that the largest disparities appear on the modest (round, orange) and moderate innovator (diamond shaped, light yellow) countries, which means that the performances of each national innovation systems are quite different. For example Hungary and Romania, which have close innovation performance level, show an important gap in their growth, in favour of the latter.



Colour coding matches the groups of countries identified in Section 3.1. Average annual growth rates as calculated over a five-year period. The dotted lines show EU27 performance and growth.

Figure 3 Convergence in Innovation performance

Table 1 Innovation growth leaders

Group	Growth rate	Growth leaders	Moderate growers	Slow growers
Innovation leaders	1.6%	Finland (FI), Germany (DE)		Denmark (DK), Sweden (SE)
Innovation followers	2.6%	Estonia (EE), Slovenia (SI)	Austria (AT), Belgium (BE), France (FR), Ireland (IE), Luxembourg (LU), Netherlands (NL)	Cyprus (CY), United Kingdom (UK)
Moderate innovators	3.5%	Malta (MT), Portugal (PT)	Czech Republic (CZ), Greece (GR), Hungary (HU), Italy (IT), Poland (PL), Slovakia (SK), Spain (ES)	
Modest innovators	3.3%	Bulgaria (BG), Romania (RO)	Latvia (LV)	Lithuania (LT)

Average annual growth rates as calculated over a five-year period.

Source: Innovation Union Scoreboard 2010, Innometrics, 2011

2.2 Innovation performance and catch up process

As we have seen, evaluating the performance of national innovation systems is not an easy thing to do. Some studies tried to evaluate the performance of the national innovation systems using CIS surveys, and their results converge with the Innovation Union Scoreboard. Edqvist and Zabala found that catch up countries perform better in process innovation rather than product innovation, and in services activities. (Edquist et Zabala (2009). Another study on the South, Central and Eastern Europe proves that the investment in the knowledge industries is weaker than in Western Europe, even when the sectoral structure of these countries is taken into account. (J. Meriküll, R. Eamets, U. Varblane, (2009).

In the field of Innovation, the situation is comparable to that of macroeconomic convergence models: the relative performance of catch up countries is higher than that of more advanced countries (Edqvist et Hommen (2008). With a low investment in knowledge activities, it is not surprising that they got a higher return than countries with higher input level in knowledge. A recent study on the efficiency of R&D spending carried out on European data confirms this point (Harfi et Mathieu (2009). The authors rank the countries according to an efficiency index calculated according to a technical efficiency model that links the RD input to their innovation capacity. This capacity is measured by their ability to create new products for the market (product innovation), or for the enterprise (imitation): we can check that the performance ranking of countries doesn't fit their level of R&D investment. For example, Romania which invests less than 0,5% of its GDP in R&D is 5th in Innovation and 7th in imitation (on 17 countries) in technical efficiency term, as Poland and Estonia whose results are far better than their R&D investment let us guess.

Tableau 2 : Mesure de l'efficience technique par pays

Pays	Effort de R&D en % du PIB	Imitation		Innovation		Global	
		%	Rang	%	Rang	%	Rang
Allemagne	Plus de 2%	68.91	3	67.54	4	74.30	2
France		66.40	10	67.83	3	72.06	4
Suède		69.59	1	69.48	1	74.50	1
Belgique	Compris entre 1,5 et 2%	64.57	13	62.33	12	70.12	12
Norvège		63.20	15	61.02	15	68.31	16
Pays-Bas		68.99	2	67.98	2	73.35	3
Espagne	Compris entre 1 et 1,5%	66.92	9	62.27	13	70.25	11
Italie		67.02	8	64.95	8	71.67	6
Tchéquie		67.42	6	64.79	9	71.32	7
Bulgarie	Compris entre 1 et 0,5%	60.46	17	61.85	14	69.64	14
Estonie		64.93	12	65.56	5	70.78	10
Hongrie		61.77	16	63.69	11	69.63	15
Lituanie		63.91	14	59.41	16	69.66	13
Pologne		68.21	4	65.38	6	71.31	8
Portugal		65.36	11	64.44	10	71.79	5
Chypre	Moins de 0,5%	67.21	7	51.39	17	64.86	17
Roumanie		67.71	5	65.08	7	71.22	9

Table 2 Source: Harfi et Mathieu (2009)

Another recent research confirms these results, since in a rather more pessimistic manner (Veugelers, 2010). Using a large panel data over 24 countries from Central and Eastern Europe, the Caucasus and Central Asia (CEECCA) countries, it tries to test their ability to develop a knowledge based growth path or to have the potential to develop in the near future. All these CEECCA Countries can be clustered according to their ability to "buy", or to "make" new technologies: it can be checked that some of modest innovators belongs rather to the first rather to the second category, while most of the newcomers in The European Union belongs to the category of Innovation active countries.

Table 3 Ranking of the CEECCA Countries by Innovation Activities

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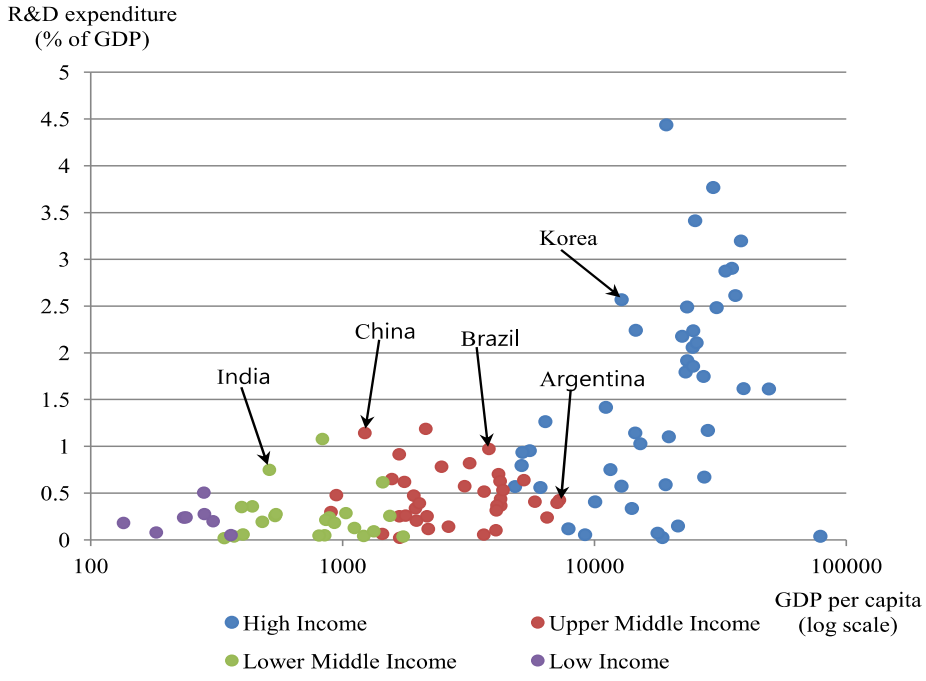
Source: R. Veugelers, Assessing the potential for knowledge-based development in transition countries, Bruegel Working Paper 2010/01

Studies carried out by Kuen Lee (Lee , 2013) leads to a more pessimistic conclusion: it shows that Middle income countries generally present low ratios of R&D, and that the relationship with the GDP per head is flat over a long variation range, as shown in the following figure. It means that the R&D Productivity know large disparities between countries, and moreover that these countries haven't any ability to rise these spending. Lee sees in this fact a main characteristics of the Middle Income Trap, which will be studied later.

Figure 4 R&D Expenditures Ratios by Country Income Group



2.3 Some Lessons from the emerging countries experience

Studies of the developing national innovation systems are still at an early stage, mainly because of the lack of data, except the case of the industrialization of East Asia, which has been widely documented, especially in the Korean case (Kim, (1980) (1997) Shin (1996). Nevertheless, recent studies have been realized, using innovation surveys with the CIS methodology.

A first comprehensive survey have been made by Bogliacino and others (Bogliacino et alii, 2010), which covers Latin America, Eastern Asia, Central and Oriental Europe, Russia, and Africa. Despite some comparability and measurement problems, some main features appear. When compared with European Union firms, which are used as benchmark, developing innovating firms have a slightly lower innovation capacity, as measured by the part of turnover in new products. Even when these countries results are close to the European ones (like Eastern Asia), most of these innovations concern new products to the firms. When considering the means devoted to innovation the gap within the European Union is deepening, this gap being mainly measured by the share of R&D spending in GDP. We find the same characteristics observed within the European Union: disparities are more important in means than in results of the innovation. Indeed, these disparities are diminishing sharply on recent years: countries like China, Brazil or Turkey having figures that will allow them to belong to the group of moderate innovators in the EIS terms. More detailed results have been obtained by recent studies on the mediterranean countries (Marocco, Tunisia) (Rigas et Hatem, 2008, Ayadi., Rahmouni, Yildizoglu,2009), using innovation survey data. They prove that the main sources of innovation are external to the firms and to the countries themselves, and that the most innovative firms are working on both the domestic and foreign market, on the contrary of "purely" exporting or domestic firms which perform poorly in this field. Another recurring problem concerns the working of the national innovation systems, still in an infant stage: most of the firms don't know the existence of national innovation support schemes, and links between the universities and enterprises are still weak.

3. Some open questions: What kind of Industrial Specialization?

At first studied in a macroeconomic framework, the analysis of economic convergence and catch up had experienced recent advances, from a theoretical and an empirical point of view. It followed the tradition of historical works initiated by Gerschenkron (1962) and Abramovitz (1986), from the study of the XIXth century European experience to the contemporary experience of Asian emerging countries (Shin (1996), Chang (2002)). While convergence can be defined according to Fagerberg and Godinho (2005) as a trend toward a reduction in differences in productivity and income in the world, catch up is linked to the process by which a late-developing country narrows its gap income ("economic catch up") and technological capability ("technological catch up") vis-à-vis a leading country (Odragi and al (2010)).

3.1 Industrial Specialization and the "Middle-Income Trap"

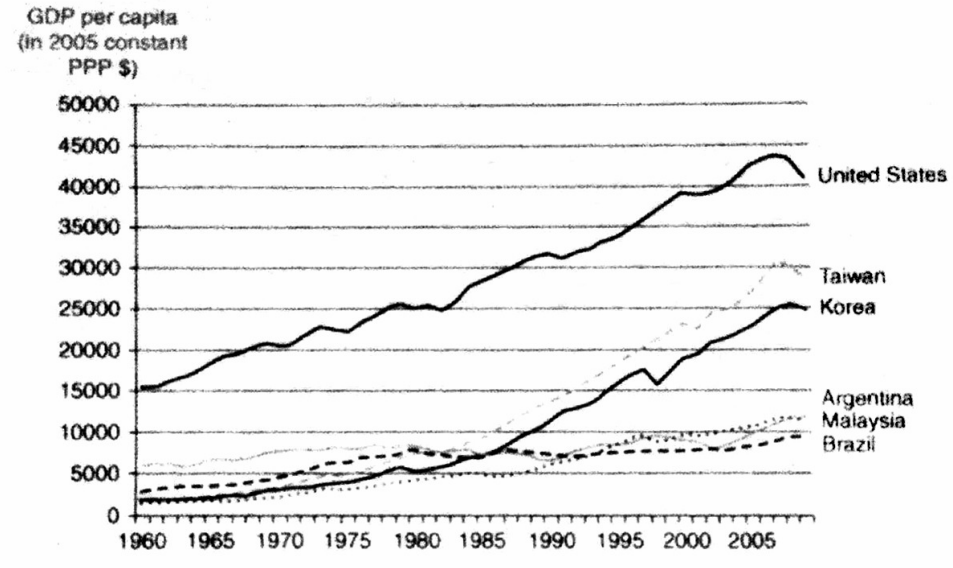
Most industrialization policies has followed the same process: using their comparative advantages, developing countries begin to set up basic industries, using low skilled labor, and after try to upgrade this specialization once they got this comparative advantage in international Trade. This process allowed these countries to leave the categories of low income countries to the middle income group.

Studies made on the Asian experience, lead by Lee (2013) question this linear process, from two points of view.

The first is that last experience from the Asian countries proved that alongside the traditional "path following catch up process", some countries has proved their ability to skip one or more steps of this process, in a "leapfrogging" strategy, or better in experiencing new stages in this process.

The second is that the linear process doesn't drive a country following it to its last stage. Some countries could be blocked in a "middle income trap": while they proved their ability to leave the lower income category to the middle income category, they could be unable to upgrade their performance and reach the highest category. Lee (2014, ibid) gives the example of Argentina and Brazil, on one side, and Korea and Taiwan, on the other side: after following the same growth path during in the 70's and early 80's, their GDP by head trajectories diverges dramatically during the 80 and 90's.

Figure 5 GDP per capita, 1960-2005.



According to Lee, this divergence is due to at first to a change in the industrialization strategy. He creates a typology in 3 categories, "Path Following" (A), "Path Skipping"(B) and "Path Creating" (C) catch up strategy (Table below).

The first strategy A, "Path Following", seems the most natural to follow:, it supposes that the country will progressively upgrade its capabilities, but it needs a long time to succeed. As it doesn't require a high level of R&D activities, it is mainly dependant on simple technologies.

So its success is largely dependant to the ability to increase this R&D expenditures and capabilities, even if they are not strictly necessary on a short term horizon.

Table 3 The three Patterns of technological Catch-up

Table 1: **Three patterns of technological catch-up**

Path of the Forerunner: stage A –> stage B --> stage C --> stage D
1) Path-Following Catch-up: stage A --> stage B --> stage C –> stage D [a]
2) Stage-skipping Catch-up (leapfrogging I): stage A ----------> stage C –> stage D [b]
3) Path-Creating Catch-up (leapfrogging II): stage A –> stage B --> stage C′ --> stage D′ [c, d]

Source: Authors.

Notes:

[a] For example, consumer electronics in Korea during analogue era, PC, and machine tools

[b] For example, engine development by Hyundai Motors; DRAM development by Samsung (Lee and Lim, 2001, and digital telephone switch development by China (Mu and Lee, 2005)

[c] For example, CDMA mobile phone, and digital TV (Lee, Lim & Song, 2005)

[d] In stage C, the two technologies, C and C′, represent alternative technologies.

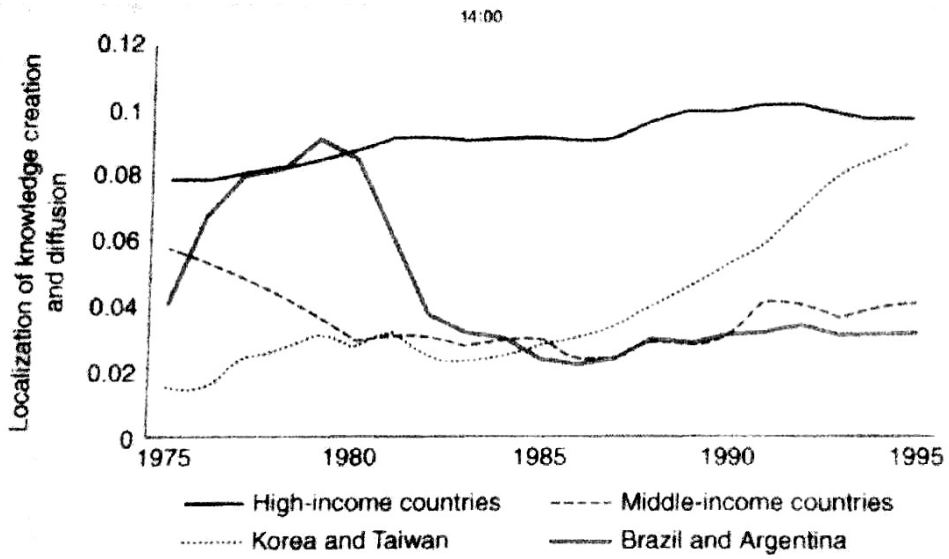
Source: K. Lee (2013)

The second and third Strategies have been followed by South Korea and Taiwan. The key of success of these strategies lies in the ability of these countries to develop “short cycle technologies”, mainly used in ICT technologies. On the contrary the middle income trap can be explained by the fact that middle income countries are generally failing in trying to develop “long cycle technologies” in the main industrial sectors. On the contrary, as short cycle technologies are changing permanently, they allow latecomers to enter more easily in these sector and to obtain competitive advantages.

The question that has to be address is linked to the capabilities these strategies require. Such capabilities need at first for the country to have an access to a large knowledge base. Park and Lee (2006) defined the accessibility to this base by measuring the share of the citations by non-G7 country (typically, a middle-income country) held patents to G7-held patents out of the total citation in a class. This variable of accessibility is positively related to the speed of catch-up, measured by the patent growth rate, and to the level of technological capability (latecomer’ shares in each class of technology).

But access to a knowledge base is a necessary, not sufficient condition to a leapfrogging strategy. It needs also a localization and a concentration of knowledge creation in the country, as they are measured by the Jaffe et al (1993) patent index. In this field the Korea and Taiwan performance is impressive, while on the contrary Brazil and Argentina exhibit a sharp decrease in this index. This divergent evolution is due to the fact that specialization of the latter in long cycle technologies made them increasingly dependant from foreign technologies – mainly, technologies coming from High-income countries.

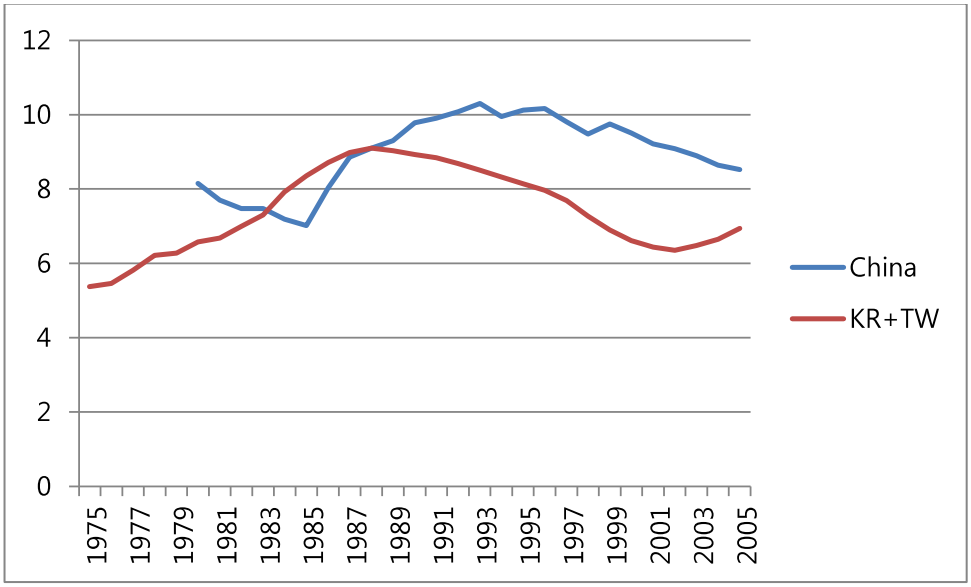
Figure 6: Localization of Knowledge creation and diffusion.



Source: Lee, (2013, p.74)

As we already said, the success of this strategy is highly depending on the choice of the industrial sectors to be promoted. Moving investment and industrial development to short cycle technologies is a crucial point. As rapid renewal of theses technologies allows middle income countries to create their own knowledge base, and to localize knowledge creation on their terriotory. As the following figure shows, China should follow the same way, if it wants not to fall into the Middle Income trap.

Figure 8 Cycle Time of Technologies in US Patents by China, and Korea/ Taiwan



Source: K. Lee (2014), Possibility of a middle-income trap in China, Frontiers of Economics in China, forthcoming

3.2 New channels for new national innovation systems ?

Another issue is linked to the channel by which Innovation is created. Catch-up strategy depends on the ability of countries to adopt new technologies, to adapt them to their needs, and to promote their own national innovation system. So the working of national innovation systems depend crucially on the way they promote Innovation Users.

National Innovation systems needs to promote Innovation Users..

According to the pioneering approach of E. Von Hippel (2005), innovation process concerns, not only its producers, but more and more its users, who are a major source of innovation product and process (Von Hippel, 1998). The development of these innovations has been boosted by the Information and Communication techniques, but it raises one question. According to Von Hippel, (Von Hippel, 2005) it will help to democratize innovation, but it is a controversial point. In fact this new innovation pattern first appeared in the more advanced countries, with an important population of high skilled "lead users", fond of new technologies and able to master and transform them. Most of the recent works on Innovation users have been done in these countries, mainly in Canada (Gault et Von Hippel, (2009)), Nederland (de Jong and Von Hippel (2008), de Jong and Von Hippel (2009)) and in Europe (Flowers, Sinozic, Patel, (2009). This last study, using the 2009 European Innovation Scoreboard is the most extensive ever. It draws a distinction between three kinds of Innovation users, named "User process Innovation", "Innovation Product Innovation", and "Involver Innovation". While the first two cover the well-known categories of innovation, the third appears when a firm decides to associate its product users to the evolution of their product. According to this study, User innovation is more developed in large firms (more than 250 and 500 employees) than in small and medium sized firms, with a slightly prevalence in middle and high technology industries. All industries are evenly concerned by this kind of Innovation. When the comparison is done between countries, User innovation is more widespread in the innovation leaders, even if the observed disparities between countries categories are rather small. On the average, in the European Union, 30,3% of firms are User process innovators, 27% innovation product innovators, and 53,1% involver innovators, a higher proportion than observed on former studies, where it reach the average of 20% of the Innovative firms.

So the main results obtained in this field prove that the firms and countries that have the highest capability to produce innovation are the most able to use it. It shouldn't be surprising: it means that innovation production and use are more complementary than substitute. Flowers go so far as calling the innovation users as "super innovators", which have to be promoted by innovation policies [87](Flowers and alii, op. cit., 2009).

[87] Let's point out that the first Free Open Source Software (FOSS) appeared in the community of computer "geeks" coming from University or computing company of the more advanced countries. Even the Ubuntu software, although born in Africa (South Africa), owes his success to its adoption in advanced countries.

How to improve the"Below the radar Innovation" (Kaplinsky et alii, 2010) ?

For the middle-income countries, promoting innovation users is a key challenge. It is important to point out that if this issue has not been well studied in these countries, it does not mean it doesn't appear. In fact, the development of ITC in the traditional sectors like agriculture and fishing (Galiègue, 2009, Jensen, 2008) can be considered as an innovation User strategy, as in a broader sense most of the strategy of technological adoption/adaptation. Others facts and arguments can be used to support this idea. As Kaplinski and alii argue, innovation should be bend to meet the needs of developing and emerging countries, and become, according to their term, " below the radar" (Kaplinski and alii, 2010). Firstly it is important to point out that the R&D expenditures of developing countries have reached significant levels: from 2% in 1990, they reached more than 20% in 2000 of the total world spending, if we count all the spending outside the Triad (Japan, USA, and Europe). So developing countries have already the technology capabilities and innovation capacity to change its pattern. A second important point is related to the change of localization of production: most of the world industrial production is now realized in developing countries, and their demand for adapted products and technology is rising. As the innovation capacity of developing countries has been created in major exporters of manufactured goods (China) or services (India), they need to follow the demand of the most growing demand potential, which is in other developing countries. As Kaplinski and others claim that developing countries should accompany and accelerate this evolution, by promoting their own innovation systems. In another words, it is necessary to promote the production and use of innovation in these countries, in making their producers and consumers new lead users.

4. Conclusion

In this survey we state that, if a catch up process is well under way for the Eastern and Southern Europe Countries, it is basically because these countries have been able to develop their own technological and social capabilities, which allow them to adopt external technology at a low cost. But if these countries want to go further in the process of technological appropriation, they need to build up their own innovation system. These innovation systems should follow the way of countries that develop short cycle technologies, an easy way to create and localize their own knowledge base. Moreover, they should also promote innovation users, who will have the ability to find use of products adapted to the needs of their enterprises and population. It is one vital condition to upgrade their innovation performance, and help them to avoid to fall down into the "middle-income trap".

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