Changes in Industry Leadership and Catch-up by the Latecomers:
Toward a theory of catch-up cycles

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ABSTRACT

This paper proposes an explanation of successive changes in industry leadership (which we call catch-up cycles) in which new firms and countries emerge in international leadership of a sector and others decline, and in which also the new leaders are then dethroned by other newcomers. This paper proposes to take a sectoral system view and, within that framework, to identify windows of opportunity that may emerge during the long run evolution of a sectoral system. Three windows related to the specific dimensions of a sectoral system are proposed: one related to changes in knowledge and technology, the second to changes in demand and the third to changes in institutions and public policy. The paper claims that it is the combination of the opening of a window (technological, demand or institutional/policy), the presence of capabilities and the appropriateness of responses/strategies by the actors that determines the changes in industrial leadership and catch up by latecomer firms. Sectors differ according to the type of windows that may open up most frequently may open up and to the patterns of change in the market shares among the key players. The paper discusses the cases of nine sectors, ranging from high technology (camera, semiconductors, mobile phones and aircraft), to scale intensive sectors (steel and shipbuilding), to service sectors (IT services and games) and to traditional ones (wine).

Key words: industry leadership; catch-up; latecomers; incumbents; cycles, windows of opportunity; strategies;
1. Introduction

Changes in industrial leadership from the incumbent to the late entrants or latecomer country are often witnessed in various industries. In the mobile phone sector, Motorola was the company that invented the mobile phone and thus created the sector; however, with the emergence of cell phones based on different standards (GSM digital technologies) Nokia took over the market from Motorola. In the smart phone era, Apple and Samsung toppled Nokia (Giachetti, 2013; Giachetti and Marchi, 2010). The steel industry is another example, as discussed in Yonekura (1994) and Lee and Ki (2013). In the first half of the 20th century, American firms dominated the production of steel but the 1970s saw the erosion of American leadership and the emergence of Japanese companies. Since the 1980s, however, Japanese firms had been challenged by a Korean firm. More recently, since the 2000s, Chinese firms have been rapidly emerging, supported by skyrocketing domestic steel demand. The shipbuilding industry also experienced similar changes in industrial leadership (Lim and Kim, 2013). American firms were in the forefront by World War II, and British firms caught up in the 1950s. From the 1960s to the mid 1990s, Japanese shipbuilders dominated this industry; after that time, Korean companies displaced Japanese firms as leaders. Such successive shifting of leadership is also evident in the automobile industry history as well: from Germany to the United States, to Japan and then possibly to Korea or China. We call these phenomena of successive changes in industrial leadership “catch-up cycles,” where catch-up means a substantial close of the gap in market shares between the incumbent/leaders and entrants/latecomers.1

Many industries witness a catch-up cycle. The incumbent fails to maintain its superiority in technology, production or market, and a latecomer catches up with the incumbent, but later on the latecomer, which has got the leadership, loses it to another latecomer. Our study

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1 In this paper, the term an entrant refers to a firm who enters into a sector later than the incumbents firm regardless of whether the firm is from the advanced or emerging countries. Although we might use the two terms of entrant and latecomer firms interchangeably in some context, the ‘latecomer firms’ (Mathews, 2002). refer primarily to firms from emerging countries. They are latecomers in the sense that when they began their manufacturing activities, the value chain of production is already well established in the market segment they enter, and already occupied by firms from advanced countries (Sturgeon and Gereffi, 2009).
attempts to explain these phenomena. How does this catch-up cycle happen? In other words, what gives entrants or latecomers an opportunity to catch up with the incumbent and take industrial leadership from them?

It is our belief that we need to have a framework for the determinants of successive catch-up cycles which goes beyond the product life cycle theory (Posner, 1961; Vernon, 1966) which concentrates mainly on the movement of production from advanced countries to developing countries. The framework that is needed has to take into account well established explanations of catch-up centered on initial conditions (Fagerberg, 1988, Fagerberg et al, 2010), macro variables (such as labor costs and exchange rates) (Katz, 1995), firms capabilities (Bell and Pavitt, 1993; Kim, 1997; Lall, 2001), and national innovation systems (Freeman, 1987; Lundvall, 1992; Nelson, 1993). These explanation went a long way to explain catching-up. But when we look at successive catch-ups, the needed framework has to go beyond these explanations. In fact it has to identify the factors at the base of successive catch-up when leadership changes again and again. In addition it has to illuminate why successive catch-up are sector specific (i.e. they may take place in a sector and not in another) with ways and intensity that may differ from sector to sector.

In this paper we introduce three factors that explain successive catching up in industries: the characteristics of the sectoral system, the windows of opportunity and the responses by incumbents and entrants to these windows. Let’s introduce these factors briefly here and discuss them more in detail in Section 2.

We start by considering a sector as a system that evolves over time. According to a definition of sectoral system (Malerba, 2002), the building blocks of a sectoral system consist of the regimes of knowledge and technologies, demand conditions, actors and networks, and institutions. These elements interact in various ways, co-evolve and generate a variety of outcomes in terms of structure, growth and performance of a sector. The characteristics of a sectoral system affect the specific opportunities for latecomers that emerge during the evolution of an industry.

Therefore, in a sector some discontinuities may emerge over time. They may correspond to one of the building blocks of the sectoral system: changes can arise at the technological level, at the demand level or at the institutional level. We call these changes “windows of opportunity”. The concept of windows of opportunity was first used by Perez and Soete (1988) to refer to the role of the rise of new techno-economic paradigms in generating leapfrogging by the latecomers who take advantage of a new paradigm and surpass the old
incumbents. Thus the first window of opportunity that we consider is a “technological window”. For example, this window can explain the forging ahead of Korean producers in consumer electronics in the digital era against the old incumbent Japanese leaders in the analogue era (Lee et al, 2005). The second window of opportunity is a “demand window”: a new type of demand, a major shake-up in local demand, or a business cycle. A major increase in demand- for example in a country such as China – or a new set of consumers- such as demand for low cost cars in India- may create the possibility of entry by new firms from a latecomer country. A business cycle creates a situation in which during a downturn incumbents may have hard time while latecomers may have lower entry cost than in normal periods (Mathews, 2005). The third window of opportunity for catching-up is an “institutional/public policy window” and can be opened up through public intervention in the industry or changes in broad institutional conditions (including some macro-variables). For example, public policy windows have been prominent in several catch-up cases, such in high-tech industries in Korea and Taiwan (Lee and Lim, 2001; Mathews, 2002), in telecommunications in China (Lee et al 2012) and in pharmaceuticals in India (Guennif and Ramani,2012).

We also observe that some firms and countries take advantage of these windows while others fail to do so. This depends on the timing of entry, the level of capabilities and the types of strategies that latecomers and incumbents have. The falling behind of the current leader is always possible and often doomed to happen as the leaders may fall into ‘incumbent trap’. By that we mean that the leaders tend to be complacent and entrenched with the current success, and not to pay attention to the new technologies, disruptive innovations, or new types of demand or growing markets. It must be noted that leadership changes tend to happen even without any apparent “mistake” by the incumbents.

So, depending upon the characteristics of the sectoral system, the nature of windows and the responses by the incumbents and entrants, different catch-ups cycles can be generated. New windows tend always to open, but may be of various types and intensity, and may greatly differ from sector to sector. In sum, the gist of our theory is that diverse combinations of windows of opportunity and responses by both incumbents and latecomers determine which pattern of successive catch-ups is most likely to emerge in a sector. Methodologically, this paper takes the method of ‘appreciative theorizing’ (Nelson and Winter 1982: 46) to provide a ‘causal explanation of observed patterns’ of the leadership changes across sectors, whereas a ‘formal theorizing’ method is used in a companion paper of Landini et al. (2013) to
generate catch-up cycles by a simulation modeling and thereby provide a formal proof of key mechanisms in leadership changes.

Section 2 proposes and discusses our own theoretical framework for the analysis of catch-up phenomenon with a brief description of the stages of catch-up cycles. Then in section 3 we present the cases of nine sectors: high technology (camera, semiconductors, mobile phones and aircraft) to scale intensive sectors (steel and shipbuilding), to service sectors (IT services and games) to traditional ones (wine). Section 4 identifies key issues and synthesizes the findings from diverse sectors. Section 5 provides a brief summary and concluding remarks.

2. A Theoretical Framework for Industry Catch-up Cycle

2.1 Current explanations: initial conditions, macro factors, firm capabilities and national innovation systems

Our starting point to look for a theoretical framework of successive catch-up cycle is the recognition that we need to consider factors going beyond the level of a single product or technology and to move to the level of a sector. In other words, although we will be dealing with competition in an industry among firms from different countries, what we need is not a firm-level but an industry-level theory that takes into account various broad variables such as technology, demand, public policy and institutions. Actually there is an existing theory on leadership changes in industries across firms and countries, but it is rather unsatisfactory for an explanation of catch-up cycles: the product cycle theory developed by Posner (1961) and Vernon (1966). The product cycle theory argues that products have a life cycle or stages (introduction – maturity – standardization). The theory also states that the cost of production is a critical factor of comparative advantage that explains the shift of production sites from developed countries to developing countries. The location of production of goods moves eventually to developing countries with cheaper production costs (especially wage rates). This well known theory cannot explain however why innovative products and production processes can be developed by firms in developing countries. Moreover, as Mowery and Nelson (1999) point out, the theory has some basic weaknesses: the theory is applied to products, rather than industries; to a single “life cycle” of a given product or technology and to industries which do not generate multiple technologies in their historical development. Lastly, the theory does not consider sufficiently the interaction of industrial and institutional elements in causing changes in industrial leadership.
If we move in search of more recent and more satisfactory explanations, four sets of variables can be identified: “initial conditions”, “macro factors”, “firm capabilities” and “national innovation systems”. Indeed these explanations are effective in explaining the emergence of a developing country from a situation of backwardness or the growth of a low income country, but, as discussed below, they do not provide a full explanation of why a country may catch up but then loose its leadership to another emerging country which may in turn decline after some time. Let’s then examine these four variables one by one.

“Initial conditions” explanations may link the growth of emerging countries to the presence of factor endowments, natural resources, culture, degree of inequality, historical legacies, legal institutions, industrial structure, degree of entrepreneurship and so on (Fagerberg, 1988; Fagerberg et al. 2011; Fagerberg et al. 2007). These conditions may push some low income countries and their firms to a phase of initial growth. However, rarely they alone are able to explain the full catching up and forging ahead of countries, and then of their falling behind to another emerging country.

Similarly, “macro variables” such as “low labor costs” as discussed in Posner (1961) and Vernon (1966) in their product life cycle theory (and examined also by several scholars that have studied the emergence of several countries, such as Korea, China, and India) can be a major source of initial catching up by countries well below the level of the leaders but often cannot lead these countries to reach world leadership. Similarly, “high exchange rates (weaker values of local currencies)” have also been mentioned as drivers of initial catching up by macroeconomists and by development economists (for example, Katz, 1995). Again, also in this case, a devaluation or a persistent low value of local currencies can be a source of initial catch-up but often does not give the spur for reaching world leadership and eventually surpassing the leaders; it cannot explain how the initial cost advantages in production or a low currency value may then lead latecomers to advantages in other dimensions like product differentiation, sectoral upgrading and innovation. For example, how it has become possible for a country like Korea which used to provide a cheap wage-based production sites to Japanese firms to rise as a formidable rival in high-end goods markets to the Japanese firms?

The “learning and capability building” of domestic firms identify a major factor that is at the base of catching up, as it has been documented by the work by Bell and Pavitt (1993), Kim (1997) and Lall (2001) among others. The long term accumulation of advanced capabilities represents a necessary condition for catching up to world leadership. But while capabilities may help explaining why a country catches up, they may not be able alone to
explain successive catch-ups, in which some capable firms from one country that caught up and reached the frontier then lose the leadership and are displaced by firms of another country.

Finally, “national innovation systems” explains catching up in terms of type and structure of the national system of innovation of a country (Freeman, 1987, Nelson, 1993 and Lundvall, 1992). Here the point is that some countries catch up because their national systems are able to induce growth and generate innovations. Government policies, regulation, public research organizations, universities, financial organizations and their systemic interactions may act in various ways to support domestic firms in their innovation and catching up. However the frame of the national innovation system does not have a proper dynamics which is able to comprise both the rise and decline of a country (Edquist, 1997), and does not focus on the differences across sectors in successive catch-up cycles.

In sum, these four factors provide good and solid explanations for why some countries catch up with respect to others, particularly if they are used jointly: for example the learning and capability accumulation by domestic firms, supported by an effective national system of innovation and by some macro factor may indeed lead countries to catch up. But these factors do not explain why some countries and their firms catch up in some sectors and reach an international prominence, and then they lose it to firms of another country, which in turn lose their its prominence to firms in another country, and so on. In other words, just combining these four variables alone may not explain the presence of successive catch-up cycles. Therefore we need a framework that, in addition to the factors discussed above, is able to explain successive catch-ups and their different features and dynamics in different sectors. This is done in what follows.

2.2 A new explanation: sectoral systems, windows of opportunity and firms’ strategic responses

The starting point of our framework is based on some empirical observations. Successive catch-ups are essentially dynamic phenomena which may take different features and dynamics, and are related to the characteristics of a sector, the advent of some discontinuities and the behavior of incumbents and followers. In fact a missing point concerning the factors explaining successive catch-ups is that the performance of firms of a certain country does not only depend only on their capabilities, on the working of some macro variables and on the role of national innovation systems, but also on how firms respond to specific opportunities
that emerge at certain moments in the evolution of an industry. Sectoral specificities determine which windows tend to open more or less frequently in which sectors, and the responses by both the incumbents and the latecomers determine which pattern of catch-up is most likely to emerge. In what follows, we elaborate our theory as a synthesis of three concepts: (a) sectoral systems, (b) windows of opportunities, and (c) responses/strategies by the actors.

The first basic point of our framework is to see industries as part of sectoral systems (Malerba, 2002, 2004). Within this perspective, firms in an industry learn and accumulate capabilities over time as part of a system composed by the knowledge and technologies that characterize the sector, demand conditions in terms of users and consumers, various actors (such as government, universities, suppliers, financial organizations, public research centers, and so on) and institutions (including public policy, IPRs, laws, culture etc.). The actors of a sectoral system are related and connected in various ways, and are involved in processes of competition, cooperation, innovation, or imitation. Seen in this way, sectoral systems evolve over time through co-evolutionary processes taking place among their various elements (Nelson, 1993). This dynamic view of sectoral system lends itself quite well for the examination of successive catch-ups. Up to now, the sectoral system framework has been applied to both industries in advanced countries (Malerba, 2004) and in developing or latecomer economies (Malerba and Mani 2009)). This framework has also been used to examine the sectoral factors that affect the success or the failure in the catching up process of latecomer countries in a specific industry (Malerba and Nelson, 2012; 2011; Lee and Lim, 2001; Lee et al., 2005; Mu and Lee, 2005; Mani, 2005, 2007). In these contributions, however, the sectoral system framework has been used for the analysis of single cases of catch-up in an industry (or failure to catch up) by firms in a country. It has not been used in order to examine in a long term perspective the emergence of diverse opportunities over time related to various changes in the elements of a sectoral system. This is what this paper aims to do.

We propose in fact that over time during its evolution a sector may have changes in one of the basic components of the system: technology and knowledge base, demand, institutions and actors. Therefore at certain points in time during its long run evolution windows related to changes in the elements of a sectoral system may open up for the late entrants: we call them “windows of opportunity” for catching up. In this paper we identify a “technology” window, a “demand” window and a “public policy and institutional” window. Here for the
sake of keeping the analysis at a tractable level we consider these windows exogenous to firms while we will come back to this issue in section 4.

The first window of opportunity is the appearance of a new technology or the introduction of a radical innovation. When a new technology is introduced or a radical innovation arrives, both late entrants and incumbents line up at the same starting line with the new technology. However often the incumbent may fall behind due to its lock-in to the existing technology in which it holds a dominant position: this is the case of the “incumbent trap” (Chandy and Tellis, 2000). The propensity for the incumbent to stay longer with the existing technology is due to the fact that its capabilities and investments are related to that technology. Moreover, because emerging technologies are often inferior or subject to greater degree of uncertainty as pointed out by the theory of S-Curve (Chandy and Tellis 1998; Foster 1986), they may generate a cautious attitude in the incumbent. Thus the leader continues to use the current technology and tends to ignore the possibly devastating potentials of new technologies or products, as in the case of disruptive innovations (Christensen, 1997). Finally, the new competences required for the new technology may differ drastically from the ones of the established leaders, so that the incumbents are not able to change them rapidly and effectively, as in the case of competence-destroying technology (Tushman and Anderson, 1986; Henderson and Clark, 1990). For example, the shift from the analogue to the digital era served as the critical momentum for the Korean electronics firm to take over the market from the Japanese firms (see the cases of display industry analyzed in Lee et al., 2005).

A second window of opportunity comes from another component of the sectoral system: demand conditions and users. It refers to the opportunity provided by the opening of a totally new demand, in which the leaders do not enter soon because they are successful within existing markets and customers. If the new demand grows rapidly, it may provide ample possibility to late entrants to catch up. The example of the Nano car in India is an example of this. The demand window refers also to the rapid growth of domestic demand, which cannot be satisfied only by exports from the leading countries or the local production of multinational corporations. For example, this is the case of the explosive growth of demand in China in some sectors which have led to the entry and growth of domestic firms. A third type of demand window refers to business cycles and/or abrupt changes in market demand. While business cycles have long been the subject of research in economics, their link to the strategic choices made by firms, especially the latecomers, seems to be less studied. Mathews (2005) and Lee and Mathews (2012) pointed out the role of business cycles serving as a
window of opportunity for latecomers in several industries characterized by large investments (such as semiconductors, shipbuilding, chemicals and oil rig operations). It is the mismatch that occurs between the dynamics of investment and production on the one hand, and the dynamics of market demand on the other, that appears to drive the cyclical behavior. In such circumstances, both incumbents and challengers must make strategic choices in terms of timing and capacity; if they fail to do so, they would be eliminated. Mathews (2005) notes that whereas upturns create opportunities for the incumbents to harvest profits and expand production, markets and employment, it is the downturns that play the cleansing role, forcing weaker players into bankruptcy, and thereby releasing resources to be picked up by stronger incumbents or by challengers looking to enter the industry. He thus argues that upturns belong to the incumbents, while the downturns (its cleansing effects) belong to the challengers.

The third window of opportunity can be opened up by public policy or by institutional changes. Government may intervene in a variety of ways: R&D programs that affect domestic firms learning process and the accumulation of capabilities, subsidies, tax reduction, export support, regulations and public standards. In a catching up perspective, the government creates an asymmetric environment in which the incumbent (often foreign) firms are in a disadvantageous position at least in the domestic market of a country (in terms of taxation, entry restrictions, marketing restrictions, subsidy allocations and so forth). Such asymmetries can result in advantages for the latecomers in offsetting the initial cost disadvantages associated with the late entry. While these interventions often are not in line with fair competition, they are sometimes justified because the incumbents often mobilize unfair measures to deter entry by the latecomers (see the discussion in Kim and Lee (2008). The cases discussed by Malerba and Nelson (2012) show how important an active government policy in certain moments of industry evolution has been for the catching up of countries such as Korea and China in several sectors. Other examples are discussed in Mu and Lee (2005) on Chinese telecommunication equipment industry and Lee and Lim (2001) and Mathews (2002) on Korean and Taiwanese industries. At the institutional level Guennif and Ramani (2012) provide an example of how the change in regulatory system gave a chance to the Indian firms in pharmaceutical industry.

Macro-institutional variables, in particular wage rates and exchange rates relative to rival countries may also serve as a window of opportunity but in a particular way. As noted by Vernon’s theory of product life cycle as well as Katz (2005), lower costs in developing
countries is the initial basis of hosting production facilities from the advanced countries and thus provided opportunity for learning for firms in the hosting countries. This overseas relocation of factories happens, among other factors, owing to high wage rates or currencies (exchange rates) in advanced countries. However, to the extent that a catching up country is successful, its wage rates are under eventual pressure for rise, and the values of currencies, under the pressure of appreciation. For instance, the Korean industries felt their price competitiveness eroding rapidly with the rising wage rates since the mid 1980s, which led to two kinds of responses. One response is to relocate their factories to Southeast Asian countries, such as Indonesia and Philippines (Lee 1994), and the other response is to launch R&D programs to move into higher-end segments or industries (Lee and Mathews 2012). The success with this twin process of intra- and inter-sectoral upgrading and globalization of production process was a decisive momentum for the Korean industries to forge ahead. Also, the Korean rise in competition against the Japanese firms in higher end products in world markets greatly benefitted from the rapid appreciation of the Japanese Yen in the late 1980s and again since the mid-1990s or the Plaza accord. Finally in the case of Hyundai Motors, its rapid rise in the US market in the 2000 got an important boost from substantial depreciation of the Korean Won as a consequence of the financial crisis in 1997. It must be noted that the discussion so far underscores the importance of macro variables in affecting the rise and decline of industries from a particular country. An important aspect of macro variables is its intrinsically endogenous nature, such that a success tends to bear a seed for destruction (rising wages and strong currency values), which may serve well in explaining not only the rise but also decline of a nation’s industry.

In sum, we claim that in the long run evolution of a sector, windows are always doomed to open as new technologies, new demand, business cycles, institutional factors and government policies are going to happen over and over again. Exactly for this reason, we take them as the sources of successive changes of leadership. However, as already mentioned above, these windows need be matched with different responses by the actors in order to generate a full dynamics of leadership changes. It is up to the firms to recognize or not the window that has opened up and to take advantage of, or misuse it and not to benefit from it.

Therefore we claim in line with the literature on learning and capability building that entrant firms may or may not be able to take advantage of the opening of a window. Let us discuss first the way late entrant firms end up being ready to grab the possibility of catching up opened by a window. Local firms in latecomer economies emerge in diverse ways: taking
over the equity shares held by the MNC joint venture partners (like Samsung’s electronics taking over the former share hold by Sanyo, discussed in Lee and He (2009), the establishment of the state-owned enterprises (like POSCO in Korea and other enterprises in China), or the growth of private indigenous firms with or without support from the government (like Hyundai Motors in Korea). In their initial period domestic companies can be OEM (original equipment manufacturing) or sub-contracting firms for foreign MNCs (like the very early days of Hyundai Motors or Samsung’s memory chip factory). These companies tend to enjoy some cost advantages owing to the latecomer advantage of adopting the latest technologies and equipment and/or have low cost workers backed up by under-valued currencies. In case of cost disadvantages at the initial stage due to the high fixed costs, smaller scale of production and no learning-by-doing these companies can be helped by government subsidies which may last until the domestic firms reach certain scale and learning efficiency. In this way, the domestic companies may gradually increase their market shares and also accumulate certain profits which can be used for investments in next stages. The accumulation of retained earnings is possible particularly when shareholders tend not to be dividend-oriented portfolio investors but long term oriented governments or family owners which prefer reinvestment for firm growth to dividend distribution. In this respects, firms in mature or advanced countries face some disadvantages as they tend to face more short-term oriented shareholders demanding dividends rather than reinvestment of retained earnings. For forward looking firms these accumulated investment funds are always ready to be mobilized in decisive manner whenever any window of opportunity opens up. Sometimes investments for new technologies are co-financed by the public actor as in the case of the Korean development of digital TV technologies (Lee et al., 2005) or of affiliates of the same business groups, as in the case of Samsung’s investment into memory chip business (Kim, 1997). While initial cost advantages would just serve the gradual catch-up in terms of market shares, it is these decisive investments in R&D, production or marketing at the moment of opening of new windows that leads to changes in the leadership of industry.

Relatedly, incumbents’ response to the opening of a window may not be rapid or effective. As mentioned before in the case of a technology window, leaders tend to be complacent and entrenched with the current success, and not to pay attention to the new technologies, disruptive innovations, new types of demand or growing markets. There are many examples, including the case of Motorola which invented the analogue-based cell phone but stayed too long with analogue technologies rather than switching to digital cell phones pioneered by
Nokia (Giachetti, 2013; Giachetti and Marchi, 2010). In other words, often incumbents tend to fall into a kind of lock-in trap of sticking to the old technology while delaying the adoption of the new. In contrast, late entrants may enjoy the advantage of being free to choose the most up-to-date technologies available.

So, depending upon the nature of windows as well as responses by the incumbents and entrants, different trajectories of industry are possible and thus different catch-ups cycles can be generated, such as the aborted catch-up, the sustained leadership one or the coexistence of the leaders and entrants. We will turn to this in what follows.

2.3. Four Stages, Three types of Cycle, and Diverse Strategies in a Sector’s Evolution

In this sub-section, we start by considering the four stages in a “standard” catch-up, following the terms first coined by Abramovitz: entry, catching up, forging ahead, and falling behind (Abramovitz, 1986). The first stage is the “entry” stage where the latecomers try to enter an industry to overcome any disadvantages by utilizing any latecomers’ advantages, such as initial conditions or macro factors such as low factor costs. The second stage is that of “gradual” catching-up in terms of market shares and/or productivity, usually based on cost advantages, as well as investments and the gradual accumulation of capabilities. The third stage is that of “forging ahead” based on the opening of windows of opportunity. This stage is often associated with the decline of the incumbents. The fourth and final stage is the stage of “falling behind” where the newly emerged leaders tend to decline with the rise of other new challengers, often associated with an incumbent trap. Of course, some leaders might be able to stay longer, not facing an immediate decline. We predict, however, that no one could last forever. These four stages can be drawn as in Figure 1.

[Figure 1] 4 Stages in Industry Catch-Up Cycle

There are two exceptions to this “standard” cycle. The first is the case of an “aborted” catch-up, in which the catching-up effort fails to generate the forging ahead stage, and companies stay stuck somewhere at the stage of gradual catch-up, which then eventually leads to a gradual decline. Actually, many latecomer countries fall into this category of the aborted catch-up. The critical barrier against them in reaching the forging ahead stage is the capability to generate upgrading into higher value-added products, especially at the time of arrival of new technologies or markets. The second case is that of “sustained” leadership, in
which the leader continues to stay on top for a long time and experiences persistence leadership. Here the leader is capable to invest in order to cope with the new technologies or demand conditions, and is able to adapt to a drastically changing environment. What we have here is that there may be the possibility of a coexistence of established companies and new entrants for some time.

As far as the speed and trajectory of individual firm’s catch-up process is concerned, it is necessary to introduce an analysis of the strategies of firms. For example, if we focus on the technological dimension of a sectoral system, latecomers can choose a strategy of path-following, stage-skipping, or path-creating, where the path means trajectory of technologies and stages means stages in the trajectories (Lee and Lim, 2001). The stage of gradual catch-up (which is present in the standard catch-up cycle) often corresponds to a path-following strategy where the late-comer moves along the same technical trajectories of the incumbent but with lower costs. In this stage, domestic firms enter often through sub-contracting (or OEM) relations with foreign MNCs or through a more direct involvement of the State in the form of the state-owned enterprises. Having a cost advantage, they adopt newer fixed capital, realize productivity increases in low end segments of the product range, and thus increase their market shares. Due to learning-by-doing, domestic firms accumulate gradually production capabilities and over time move up the quality ladder of products and technologies.

The forging ahead stage often tends to be triggered by a strategy of stage-skipping or path-creating, combined with radical change in technology or in demand conditions. A stage-skipping strategy refers to the case of latecomer firms following the same path as the incumbent but skipping some stages, thus saving time to catch up. On the contrary a path-creating strategy refers to exploring one’s own path of technological development by taking advantage of a new radical innovation or a new generation of technologies. This way, a latecomer can create its own path, which is different and diverge from its forerunners (Perez and Soete, 1988).

Down the road toward catch-up, a successful latecomer may encounter challenges from the next tiers of latecomers. Thus latecomer firms often face a new challenge of being sandwiched by new followers and old leaders. Successful cases of catch-up stories indicates that such crisis are overcome by upgrading toward higher end segments (Lee and Mathews 2012) or by taking a risky strategies of leapfrogging, either stage-skipping or creating a new path. Which types of organization (such as business groups or specialized small and medium
size enterprises) is better suited for this type of strategy, depends on the relationship with the type of sectoral system (Kim and Lee, 2003; Park and Lee, 2006).

As a final remark, we may note that during the full catch-up cycle different windows of opportunity can open up at certain stages. In the entry stage, government may play a role. For example, for the entry of latecomer steel firms, the role of the governments was very critical both in Japan and Korea, as the government supplied a big chunk of investment funds. In the entry stage, also a window opened by business cycles can be utilized, as explained with the case of the TFT-LCD industry (Mathews, 2005) and the case of the Korean entry in the steel industry. The same downturns can also be a momentum for gradual catch-up or even forging ahead of the latecomers as some incumbents tend to collapse during downturns. The 2008 American financial crisis almost killed or set a sudden brake on the leaders, and Hyundai Motors was the biggest beneficiary of the crisis. In the stage of gradual catch-up, government regulation against foreign incumbent firms can help the latecomers to increase their market shares by creating asymmetric conditions for market competition. This for example is often used by the Chinese government in many strategic sectors. For the stage of forging ahead radical new technologies may create a window that allow latecomers to become leaders, such as the shift from analogue to digital technologies. An example is the success of the Korean electronics firms against the Japanese incumbents. It must be noted that one or more windows of opportunities can also open together and sometimes in sequences. For example, as analyzed in Lee et al. (2014) in the case of IT service sector in India, the occurrence of a new technology and the regulatory changes on the foreign firms served as the windows of the opportunity for domestic Indian firms.

In what follows, we will briefly examine some examples taken from the cases of several industries, where the focus is on successive catch-ups in the long term evolution of an industry.

### 3. Successive catch-up cycles and leadership changes in the long-run evolution of different industries

Successive catch-up cycles can be identified in several sectors. In what follows, we will briefly discuss the cases of nine sectors, ranging from high technology (camera, semiconductors, mobile phones and aircraft) to scale intensive sectors (steel, shipbuilding),
3.1 Mobile Phones

We analyze changes of industrial leadership in the global mobile phone industry, from its inception at the beginning of the 1980s, when the first handset was introduced into the market, to 2012, the heart of the technological convergence revolution. The first change is the passage from analogue to digital mobile phones, when Nokia dethroned Motorola. The launch of the digital technology at the beginning of the 1990s marked a relevant technological discontinuity: the sudden redundancy of first-generation analogue devices and the rise of second-generation services and equipment. The GSM digital mobile technology, launched in Europe in 1991, offered superior performance with respect to the analog system. Handsets working with GSM were commonly called ‘second-generation mobile phones’ (2G). Motorola ignored the success of digital technologies and continued to rely heavily on analogue technology believing that customers would prefer analogue phones compared to digital phones. By understanding the analogue–digital system discontinuity, and how the company could benefit from it, Nokia was encouraged to commit earlier than its rivals to the emerging mobile communication standard, to focus on base station development in the GSM European R&D alliance, and to start building relationships with the newly franchised independent mobile network operators. Nokia dethroned Motorola in 1998.

The second change is the passage from regular phones to smart phones, when Samsung and Apple dethroned Nokia. The advancement in technology gave birth to a new category of phones: ‘smart phones’. The entry of Apple’s iOS and Google’s Android OS in 2007 changed the face of the smart phone market. Unlike the older mobile operating systems like Symbian, iOS and Android OS were custom built to support the touch interface which gained popularity with consumers. Globally, Android became the highest selling smart phone operating system. Nokia was not able to manage properly the transition from regular phones (low-end market) to smart phone (high-end market) at the end of 2000s. Differently from Nokia, the first mobile phone vendor that incorporated Android OS was Samsung. The success of Samsung in the second half of the first decade of the 2000s was mainly fostered by

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2 The case of mobile phones industry is drawn from Giachetti and Marchi (2013).
the growing popularity of their Android based smart phones (which were competitors to Nokia Symbian-based phones and Apple’s iPhones). Samsung dethroned Nokia in 2012.

3.2. Cameras

This industry has seen three major technological shifts. While two of them allowed shifts in industrial leadership, one allowed the incumbents to maintain market shares. The first leadership change happened from Germany to Japan. After the birth of a fixed (or installation type) camera, a rangefinder (RF) camera opened up the era of portable camera with the German companies leading the market. Japanese firms in early days learned German technologies and imitated RF camera, and then in 1950s created a new technological path to a single lens reflex (SLR) camera by solving two problems in the RF camera with radical, competence-destroying innovations. World War II increased demand for (optical) military equipment, and knowledge transfer from Germany to allied Japan had also been a learning channel for Japanese firms.

In 1980s, the second generation shift – from analog SLR to digital SLR (DSLR) – hit the market. However, because DSLR technology was built largely upon existing SLR technology (except for the image sensor) this competence-enhancing discontinuity resulted in continuation of the leadership of established firms: Canon and Nikon. To catch up with these incumbents, several latecomers pioneered a new technological trajectory (a compact system camera: CSC), which represents the third generation shift. Despite this arrival of new technologies, Canon and Nikon remained focused on improving DSLR technology until very recently. This can be considered an example of incumbent trap behavior. However it is too early to make a final evaluation as some changes are now taking place. In contrast, late entrants such as Sony, Olympus and Samsung joined the CSC camp with speed and in timely manner and enjoyed rapid growth.

3.3 Steel

Steel industry has seen two times of leadership changes. The first one was from the US to Japan in the late 1970s and early 1980s, and the second one from the Nippon Steel to POSCO

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3 The case of camera industry is a summary based on Kang and Song (2013).

4 The case of steel industry is drawn from Lee and Ki (2014).
in Korea around the late 1990s. In the first leadership change from the US to Japan, the window of opportunity for Japan was the appearance of new technologies, basic oxygen furnace (BOF) and continuous casting (CC). While the latecomer Japanese steel firms rapidly adopted the new technologies, the US companies kept the old or existing methods for a while. Again this can be regarded as the example of the ‘incumbent trap.’ By 1970, Japan’s adoption ratio stood at 95 percent compared to 56 percent of the US. (Yonekura, 1994). Why did the US firms and the Japanese differ in adopting the new innovation? First, the useful economic life of the existing facility had not ended yet when the BOF started to be put into commercial operation in the mid-1950s. Since the late 1960s, the Japanese forging ahead stage had been boosted with another radical innovation (CC) which was put into industrial use widely in the 1960s. Also this innovation was widely and rapidly adopted among the Japanese firms compared to the US firms (D’Costa, 1999; Yonekura, 1994). The case of Japan adopting quickly the newly emerged technologies of the BOF and CC can be considered as a path-creating strategy.

In the rise of Korean steel industry (represented by POSCO) against Nippon Steel in Japan, the global steel industry’s downturns and the Korean government’s industrial policies served as windows of opportunity. Owing to the business downturns in steel industry during and after the two oil shocks, POSCO was able to purchase old production equipment at lower cost during the initial set-up of the factory in the early 1970s, and then state-of-the art technologies during its expansion in the mid-1980s. So, the first case can be considered as an example of the path-following entry and the second case of a stage-skipping catch-up. Initially, POSCO entered the lower-end segment of the steel product, and gradually moved into higher-end segments.

3.4. Shipbuilding

Shipbuilding had two changes in industry leadership. The first change was from UK to Japan in the late 1950s, and the second change was from Japan to Korea in the early 2000s. The first change was due to a window of opportunity related to a new technology- the wielding

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5 In the case of Korea-Japan comparison, we consider only the leading firms in two countries rather than the whole steel industry of two countries. This is because the POSCO was only the integrated steel firm in Korea.
6 The case of shipbuilding industry is drawn from Lim and Kim (2013).
block- which was widely used by Japanese shipbuilders in commercial vessels. Japanese producers were able to develop products at the technological frontiers- coupled with a high growth of world demand for large ships. Japan became the leader in the production of oil tankers, bulk carriers, cargo ships and gas and chemical carriers. UK lagged behind because of the late adoption of new technology due to the resistance of the trade unions to the welding block method.

Later on, in the early 1970s, Korea entered the industry due to a window related to government policy. The Government supported the industry with preferential rates from state-owned banks, export loans to shipbuilders, investments in new infrastructure facilities related to docks and protection of the (small) domestic market. In addition the government supported local production of steel. Local companies such as Hyundai and Samsung started to develop their capabilities in production technology and were then able to profit from an upturn in the demand from the 1990s on, when demand for large vessels was heterogeneous in their requirements and interaction with customers was possible by the digitalization of design activities which allowed customization strategies. Japanese companies did not follow Korean companies because they focused on standardized products for a demand considered homogeneous. Moreover they did not have enough human resources for design activities. Therefore in the early 2000s Korea surpassed Japan in the production of oil tankers and in container ships.

3.5. Semiconductors

Memory chip segment in semi-conductor has seen two times of leadership change, from US to Japan and then Japan to Korea. According to Kim and Lee (2003), technological regime of the memory chips is featured by frequent but ordered and predictable changes in generations of technologies (like 1k to 16k, 64k, and 128k bit memory chips -DRAM, dynamic random access memory). In terms of market regimes, re-occurring business cycles with ups and downs of prices of chips have been present. These two features have led to a particular catch-up strategy of late entrants. Both Japanese and Korean chip makers adopted a dynamic catch-up strategy of conducting investments over two overlapping generations of chip

7 The case of semiconductors industry is drawn from Shin (2013).
simultaneously. It can be considered as a variant of leapfrogging strategies, which was possible due to the somewhat predictable nature of technological trajectory and the late entrant firms’ perception of the incumbent firm as a moving target. While such features seemed to have played the role of windows of opportunity for Japan and Korea, now the window seems to be getting narrower or even closed, as can be seen from the fact that Samsung has maintained the leadership for the last two decades. This is due to the arrival of a new technology called flash memory replacing DRAMs. This innovation is competence-enhancing: the existing manufacturing facilities in DRAMs do not have to be scrapped but can be used to produce flash memories.

3.6. Aircrafts: regional jets

The regional jet industry witnessed two instances of leadership change in the past three decades. In the first instance, British Aerospace (BAe) and Fokker, the European incumbents in the sector with their product line covering the 70-120 seat ranges, lost their leadership position to Bombardier of Canada. Bombardier was the first to respond to a combination of windows of opportunities that created a niche for the 50-seat market (previously only served by turboprops). More efficient jet engine technology, cheaper oil prices, market liberalization and the expansion of regional services boosted by and the introduction of scope clauses created technological, demand and regulatory windows to which Bombardier responded with a radical innovation (the creation of the CRJ200 jet based on its experience in business jets) and with a very efficient lean manufacturing process. BAe and Fokker continued with their existing strategy of addressing the 50-seat market with turboprops: apart from the sunk costs in their 70-120-seat jet and 50-seat turboprop product line, they assumed that oil prices would not be sufficiently low and customers would prefer lower prices rather than convenience and minimal speed gains. During the 1990s however, demand for 50-seat regional jets significantly exceeded demand for 70-120-seat regional jets, and thus Bombardier, the first efficient producer in the 50-seat segment became the market leader. At the same time, the shrinking demand for larger regional jets made it even more difficult for the too costly European producers to reach output volumes critical to recover development costs, forcing them to eventually exit the industry.

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8 The case of aircrafts industry is drawn from Vértesy (2013).
A second leadership change occurred in 2005, following the opening of new demand and regulatory windows of opportunities. This time, oil prices hiked, the air transport market became ever more competitive with the arrival of low-cost carriers. The 70-120 seat market increased at the expense of both the 50-seat regional jet market as well as the 150 seat "large civil jet" market. On the one hand, ‘scope clause’9 limitations were relaxed from 50 seats to 70 and even greater; on the other hand, fluctuations in the world economy resulted in regional and mainline carriers becoming increasingly inclined to right-sizing aircraft for demand. Rather than to pay the cost of unused capacity, airlines opted to shrink aircraft size and operation costs. As a result, regional jet sales became the strongest in the 70-120-seat market. The Brazilian Embraer, with its already proven design, manufacturing and marketing capabilities in the regional jet industry was the first to make a strategic choice to address the 70-120 niche by developing a new product line, the ERJ-170/190 specifically intended for this market with more advanced technology than existing products. Bombardier also recognized the same window of opportunities, but decided to stretch the existing CRJ product line and boost revenues with less investment rather than opt for a risky choice of a clean-sheet design. Although this way Bombardier defended its positions in the market segment up to 100 seats, the demand window continued to shift to larger jets which made Embraer virtually the only producer to serve the 100-120 seat range which accounted for the bulk of sales and thus gained leadership.

3.7. Games10

The game industry suggests a story of leadership change from the US to Japan and then from Japan back to the US. In the first leadership change the window of opportunity for Japan was a market crash in the US in 1983–1984. Nintendo, a Japanese firm producing toys and playing cards, took advantage of this vacuum by developing a strictly regulated, closed-system platform, in which game software was tested, approved, and given a secret code to

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9 Scope clauses was an agreement between the big airlines and pilot's unions to defend the higher wages of larger airlines’ pilots against the lower wages paid by regional airlines, which were subcontracted to fly commuter routes. In order to keep a cap on the upward extension of relatively cheaper commuter services, pilot unions and airlines settled with the agreement that subcontractors cannot fly aircraft larger than 50 seats. The cap remained flat at around 50 seats for most of the 1990s, only to increase upward (70-90 seats) towards the end of the decade and the early 2000s in light of higher oil prices and economic turmoil.

10 The case of games industry is drawn from Izushi and Aoyama (2013).
avoid piracy. Nintendo was joined by Sony in the 1990s, thereby cementing the global dominance of Japan. However, since the 1990s new information and communications technologies were adopted in video games. Combined with the use of the CD-ROM as a storage medium, this US-led development in software technology unleashed competition over detailed graphic presentation, allowing US software firms to regain market shares. The dominance of Japanese firms in game console manufacturing ended in 2001 also due to the release of Xbox by Microsoft which employed its software engineering skills to greatly enhance graphic representation. Solidifying the demand for console games by creating a group of consumers now known as “hard core” gamers, the entry of Microsoft marked the return of the US game industry to a leadership position in the first decade of the 2000s. The leadership position regained by the US has been consolidated by the recent growth of mobile phone-based games that use social networking as platforms.

3.8 IT services

In IT service, the USA used to be the world leader, given its supremacy in computer hardware. However around the late 1980s, given the high cost of development, US companies began to outsource the production of computing software services to Ireland. Since then, Ireland had risen as a new site for the software industry, with rapidly rising share in world export markets. However, the success of Ireland pushed its wage rates to higher levels, which induced foreign MNCs to relocate their factories outside of Ireland. Thus, Ireland had to see weakening of its software industry because it did not have much locally-owned software companies. Furthermore, there was a rise of India.

The change in leadership occurred when India became the largest IT service provider in the world. Besides cost advantages, India’s IT service sector profited from some windows of opportunity: the emergence of new business models of offshoring, the shift from hardware technology to client–server in the late 1980s that created a new, a huge source of demand for customized software, and some exogenous events such as the Y2K problem and the ‘dotcom boom’ in the US. In addition, there were changes in government regulations, such as the Foreign Exchange Regulation Act (FERA) of 1973 to conserve India’s foreign exchange resources, and the post-1991 liberalization. Finally, when IBM decided to leave India, the Indian government acquired India-IBM, nationalized it, and renamed it CMC, which then

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The case of IT services industry is drawn from Mani (2013) and Lee et al (2014).
was acquired by TCS (Tata Consulting Service) in 2002. As a result, various capabilities previously monopolized by India-IBM (such as mainframe support system, infrastructure, skill and human resources) were transferred to TCS during the nationalization period. The exit by IBM, the demand of some foreign computer companies of software products, and the acquisition of CMC by TCS was a major milestone in the latter’s technical progress that gave Indian programmers the opportunity to acquire technical capability and improve their skills in the process.

Different from Ireland, India’s IT services industry became much more innovative both in terms of the number of patents granted or in terms of going up the value chain. There are now many instances of reverse innovations where innovations are first developed in India and then transferred back to developed countries. Indian IT service companies, such as three giants of Infosys, WIPRO, and TCS, are all locally-owned but listed on New York Stock Exchanges, and have moved up the value-chains to be in charge of the high-value-added segment of the industry. So, while the initial story of the rise of Ireland is consistent with Vernon’s product life cycles, India’s rise as an independent rival to the US is beyond the Vernon’s theory and it is related to the emergence of various technological, demand and government windows.

3.9. Wine

Until the end of the 1980s the international market for wine was dominated by the European countries, particularly by France. Since the early 1990s this supremacy has come under attack. In this first change of leadership, two new global leaders emerged, namely USA and Australia. More recently (approximately since 2005), a second change in global leadership is occurring, with France being overcome by close a follower, Italy. There were three windows in this industry: first, in the 1990s the rise of new inexperienced consumers from the UK, the USA and the Scandinavian countries; second, at the end of the first decade of the 2000s a strong demand for more sophisticated and varied wines both in the new and in more traditional markets, and finally, a recent upsurge of the Asian market. There were also opportunities related to technological innovations.

With regard to the first change in the leadership, the new production pattern developed by New World producers was characterized by technological modernization, product upgrading and marketing innovations, consistent with the changes in demand. Indeed, innovation has

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The case of wine industry is drawn from Morrison and Rabellotti (2013).
been largely market-driven, aimed at solving problems related with output variability, quality and adaptation to international taste. With respect to the second change, in Old World countries some producers have responded to the increasing competition from New World countries by upgrading quality and adapting wines to new tastes. In sum, in this sector, we do not observe a complete replacement of the old leaders by the new entrants but the co-existence of the old and new leaders.

4. Key Findings and Issues

From the cases of successive catch-ups in the long-run evolution of different industries examined in section 3, let us try to answer the key research questions of this paper, namely why and how the leadership changes tend to occur again and again, why the incumbent cannot maintain the leadership forever, and how late entrants are able to enhance their competitiveness to threaten the incumbents.

4.1 The Driving Forces of Successive Leadership Changes

We find that the phenomenon of frequent or unexpected arrival of new technologies and innovations holds an answer about the forces of successive leadership changes because disruptive innovations are perceived and reacted differently by the leaders and followers. For instance, the camera industry had the Japanese revolution of single lens reflex (SLR) camera replacing the German technology of rangefinder (RF) camera; the mobile phone industry had a paradigm shift from analogue to digital technology with leadership change from Motorola to Nokia; the steel industry had the radical innovations of BOF and CC which pushed Japan to the leadership against the US; the rise of Japan in shipbuilding was owing to the adoption of a completely new technology - the wielding block method. In this light, we may call major innovations as a window of risk for the incumbents unless they use them for further increase of market shares.

The role of demand disruptions or business cycles is basically similar to that of new technologies as another window of opportunity. For the Indian IT service sector, the two exogenous events of Y2K problem and ‘dotcom boom’ in the US were quite critical. For the wine industries, the windows were first the rise of new inexperienced consumers from the UK, the USA and the Scandinavian countries; then at the end of the 2000s a search for more
sophisticated and varied wines both in the new and in more traditional markets and finally, recently, the upsurge of the Asian market. In the rise of the Korean firm in steel was helped by the recession caused by the two oil shocks; the semi-conductor (memory chips) had had a frequent but ordered and predictable changes in generations, like 1k to 16k, 64k, and 128k bit memory chips, which generated business cycles. In regional jets, technology and demand windows worked together. The new technologies that mattered for leadership change regarded more efficient jet engines (with higher bypass ratio), while demand disruption regarded changing oil prices.

While the technologies and demand windows can explain the leadership changes among the players with similar (or not so distant) level of technological capabilities, they are not enough to explain the rise of new leaders from the developing or emerging countries whose level of technologies used to be quite low or distant, compared to those in the advanced countries. This is where Vernon stopped but that is where we are departing. Vernon (1966) stopped at pointing out the phenomenon of factory relocation to emerging countries with lower wage or cost conditions. We note that the initial factor cost differences and related factory relocations is a favorable initial conditions (or initial window of opportunity) for the latecomers to learn the existing technologies (learning by doing) and thereby generate some revenue for further investment in production technologies. For this reason, initial catch-up in market shares by the latecomers often realizes in low end segment of the sectors, as in the case of steel and software (Lee and Ki, 2013; Mani, 2013). This kind of catch-up based on factor cost advantages are not rare but does not automatically lead to the eventual reversal of market shares between the incumbent and the latecomers unless the latecomers acquire higher level of capabilities (technological capabilities) combined with local ownership of both production and R&D. The case of software industry in Ireland, which rose rapidly in market but then declined, shows that firms in Ireland were foreign owned and that multinational companies went to Eastern Europe and other locations to seek lower wages rates when wage rates were rising in Ireland. The Irish firms did not consolidate their own technological capabilities and thereby failed to move into higher end segments in the same industry (Mani, 2013). In contrast, as in several of the industries examined in Section 3, the Korean firms in various sectors were more or less locally-owned and tried hard to build up their own innovation capabilities required to move into higher-end segments or newly emerging industries so that they may maintain competitiveness even with the rising wage rates in their home markets.
To explain the process of building technological capabilities in emerging economies, this paper has shown that we need to call in another window of opportunity related to institutions, in particular the role of government and public research labs. In industries, such as steel, shipbuilding, and cell phones (examined in Section 3), the role of government was critical and different from sector to sector, such as entry by a SOE in steel (Lee and Ki, 2013), infant industry or market protection in shipbuilding (Lim and Kim, 2013) and mid-sized jets (Vértesy 2013), and public-private joint R&D and exclusive standard policy in mobile phones (Lee and Lim, 2001). We can also claim that in sectoral systems in which economies of scale are important the role of government in protecting the initial market is important, due to the high costs per unit for a small initial volume of production.

4.2 Incumbent Trap: Mistake or Rational Decision-making?

The analysis so far indicates that the likelihood of leadership change increases when the technology windows are combined with a behavior of the incumbent that can be considered as the ‘trap.’ However, with regard to the choice of adopting or not new technologies, the trap may be a trap only in an *ex post* sense. In their early days, new technologies are often more costly, less productive, and less reliable. Thus, the incumbents who command the highest productivity from the existing technologies feel no reason to adopt new technologies. Thus, it is not certain whether the choice by the incumbents is simply a mistake or an *ex ante* rational decision-making. The boundary of the incumbent trap concept can be broad enough to include diverse cases including the case of the ‘innovator’s dilemma’ of whether or not to introduce innovations that are detrimental to its current business (Christensen 1997). An example case of this broader definition of incumbent trap is the case of Motorola which tried to improve further the existing analogue telecommunication technologies despite arrival of digital technologies. Giachetti (2013) and Häikiö (2001) observe that even when the digital standards were quickly diffusing in many countries due to their superior technical performance with respect to analog standards, Motorola persisted to invest heavily in analog mobile phone technologies, believing that customers would accept the technological trajectories imposed by its leadership. In 1995, Motorola top management came up with a program called “Signature” to promote the company’s new analog phone, the StarTAC, priced more than $1,000. However the largest network operators, like AT&T, refused to participate in the program.
The cases of the sectors addressed in this paper indicate that sources of the incumbent trap phenomena can be quite diverse. Misjudgment could happen also with regard to estimating the potentials of new markets (e.g. in emerging countries) versus existing markets (in developed countries). In other cases, as in the case of steel, one of the reasons that American steel firms did not adopt the BOF was simply because US steel firms constructed many mills with the old method of open hearth furnace before the mid-1950s and thus the useful economic life of their OHFs did not end yet when the BOF started to be put into commercial operation in the mid-1950s (Yonekura 1994). This case cannot simply be called a mistake or case of an innovator’s dilemma. In this case of involving the life expectancy of existing capital stock, the incumbent cannot help falling into the trap whenever a new innovation emerges before the end of a current life-cycle. In regional jets, at the end of the 1980s, when Bombardier was making strategic moves to respond to the demand window opened for smaller regional jets, BAe and Fokker, the incumbent regional jet producers had valid reasons not to follow suit. Outlooks for lower oil prices were uncertain, it was a fair assumption that airlines, increasingly price sensitive in the increased competition due to liberalization in air transport services, would buy more of the cheaper 50-seat turboprops than jets. Adding to it the significant sunk costs in the development of their existing product line, it is hard to question their rationale for trying to make use as much as possible of the economic life cycle of existing products. (Vertesy, 2013)

Finally there are also cases of a ‘trap’ from other reasons. An example is the case of UK shipbuilders which delayed to adopt the new technology or the welding block due to the opposition of trade unions because the work done by four workers in the old rivet method could be done by one worker under the new method. Due to the delayed adoption, UK firms were not able to compete with Japanese shipbuilders which enjoyed shorter delivery time and improved productivity from the adoption of the welding block methods (Cho and Porter, 1986).

4.3 Sectoral Specificities of Windows and in the Pattern of Leadership Dynamics

The analysis in Section 3 has revealed differences across sectors in the sources, patterns and dynamics of leadership changes. Sectors differ according to the type of windows that most frequently open up and in the type of catch-up cycle. In sectoral systems in which knowledge and technology changes rapidly, such as semiconductors and mobile phones, there is a high probability that technological windows are likely to open up and play a major role.
In other sectors in which technology does not change frequently, such as wine and auto, demand windows may act as a factor for the emergence of new leadership. In these sectors, however, even when there is a rise of new companies or countries, the new firms often co-exist with old incumbents rather than replace them completely (as the case of wine in section 3 shows; Morrison and Rabellotti, 2014). A history-friendly model of successive catch-ups in industry evolution (Landini et al., 2014) also confirms that it is the technology windows (particularly those large in terms of technological advancements), and not demand windows, that lead to a quicker and radical reversal of market shares among the defenders and challengers.

In sectoral systems in which radical innovations are less frequent, the institutional setting is important for the coordination and support of economic activity. This is particularly relevant in the case of industries with high economies of scale, such as in regional jets and steel. In these sectors government windows may play a critical role in the rise of new entrants. POSCO in Korea was started as a monopoly SOE; both Embraer and Bombardier received critical support from the government (including public procurement and marketing abroad). However, also in a high-tech sector like cell phones, the role of government (in particular standards and regulation) may be important in different aspects. The divergent path of Nokia versus Motorola was affected by the different standard policy in the US (market-driven; allowing multiple standards) and Europe (coordinated; promoting single standard) with regard to 2G standard in wireless telecommunication (Giachetti 2013; Giachetti and Marchi (2014). This indicates that in a sector with strong network effects standardization policy can be a key tool for public policy, compared to traditional tools of market protection or tariffs. Moreover, the role of standards is also important in affecting the probability of success of a leapfrogging strategy, as shown in the case of leapfrogging into digital TV technology by the Korean consortium. Here, leapfrogging involved two kinds of risks: the risk of how to choose the ‘right’ standards out of several alternatives and that of how to create the initial demand for the new standard (Lee et al 2005).

There are cases of sectoral systems in which both technology and demand windows opened up. For example, in steel a technology window related to a radical change in technology served Japan to take a leadership away from the US, and then a demand windows associated with business cycle downturns served Korea to enter with the existing technologies but at a lower cost. One final note on the sector specificity refers to the type of innovations. As shown in Section 3, in sector like camera, both competence-enhancing and
disruptive innovations were present. The emergence of digital camera was not disruptive so that Canon continued its leadership in both analogue and digital periods, generating a sustained cycle. However, the more recent innovation of mirror-less camera has been more disruptive with the rise of new leaders, such as Sony (Kang and Song, 2013)

4.4 Exogeneity or Endogeneity of Windows

In our framework, we have considered windows as exogenous, occurring at certain moments of the evolution of a sectoral system. But we also note that windows can be endogenously created by the very actors within the sectoral system that aim to increase the possibility of changes in leadership. One case is a technology window which results from the R&D investments by the firms in completely new technologies. Another is a window related to completely new demand which has been addressed and opened up by the R&D and marketing search efforts of latecomers firms. Another one is when new public policy is the result of a lobby of the latecomer companies in a country that aim to catch up.

While this can be a new topic for research, our cases seem to have some helpful guidance for direction of future research. First, the degree of exogeneity or endogeneity of new innovations might depend upon who is initiating the technological changes. From the point of view of the current leaders, they may have a reason to lead, if possible, innovations into the direction of competence-enhancing way, when they are faced with several alternative directions for technical changes. If the leaders succeed in this direction and are able to make it become an industry standard, they are more likely to maintain their leadership in the next generations. This might be the case of Samsung’s memory chip business where Samsung has been able to be the leader since the late 1990s, despite the industry had seen several leadership changes before the rise of Samsung (Shin, 2013). Of course these cases apply to certain technologies, like semiconductor memory chips or capital goods that have a high barrier to entry rather than final consumer goods such as cell phones that are subject to more rivalry and uncertainty.

An emerging strategic implication is that for leaders an effective strategy to keep their leadership for a longer period is not to face the situation in which one has to adopt or not exogenous innovations but rather the one of keep taking a lead in innovation. In a sense the
leader has to ‘endogenize’ technological change in a direction of its own benefit. In contrast, for the followers (laggards or late entrants), technical changes might come as something more exogenous, so that they may have to choose which alternative technologies or standards to follow. In some cases, the boundary between exogeneity and endogeneity is quite blurred. As discussed for cell phones (Giachetti and Marchi, 2013), a completely new OS (Android) for smart phones was developed by Google, and then it was that firms’ endogenous decision-making whether to adopt this standard or not. Whereas Samsung adopted it to generate a success in new smart phone market, Nokia refused to take that by Google and stuck to its own OS which then became the major cause for its downfall in markets for new phones (smart phones). Given that Google is also making and selling smart phones, the same technology (a new OS) was endogenous technology for Google but exogenous for Samsung and others. This suggests that whether a technology is exogenous or endogenous depends upon each case. However for the followers or laggards, the exogeneity assumption may be more justified.

We also note an interesting case which may be called a strategy of ‘endogenizing exogenous innovations’. An example is Samsung’s co-development (in its early stage) of CDMA wireless technologies with Qualcomm (Lee and Lim, 2001), as well as world-first development of digital TV set by the Korean public-private R&D consortium (Lee et al., 2005). In both cases, the initial development of technologies was happening in the advanced countries. But, the latecomer (the Korean consortium) quickly identified the first mover (which is Qualcomm in the case of CDMA technologies) to work together for commercializing the developments of the source technologies by the first mover. In the case of digital TV, the Korean consortium had been watching as an outsider the progress of standardization process among the key players in the advanced countries and quickly developed a digital TV compatible with the finalized standard (the so-called ‘grand alliance’) agreed among the key players (Lee et al., 2005). This strategy of endogenizing at early stage the exogenously emerging technologies may be one of the key ingredients of the successful leapfrogging by the latecomers and is related to the concurrent presence of advance capabilities by latecomers.
More controversial is the case of government or public policy window. Simply, some actions and measures taken by the government are exogenous to firms, whereas some other actions may have been lobbied by the firms in a sector. An extreme case is when the government established a state owned enterprise (SOE) to enter a sector, like the case of POSCO in Korea. It was an exogenous action by the government but cannot be regarded as window of opportunity for firms as the government itself tried to create a window for itself or for a country’s sector. The case of regional jets (Vértesy, 2014) illustrates a situation where institutional conditions were influenced by producers with a large enough size and power or by a strategic collaboration of leading companies and their government (such as the creation of favorable tax conditions or an export financing regime). Yet the effectiveness of such “tinkered” opportunities in the longer term may depend on the existence of other windows of opportunities (such as demand or technology windows) combined with other dimensions of strategic actions by the firms themselves. The case of steel in Korea is an example of combination of exogenous demand window and a government window which is more or less endogenous. Some actions by the government were launched at a sectoral-level to promote steel industry but in reality there was only one firm (POSCO) that was able to satisfy the specific conditions to get government support.

Finally, even macro variables are, to a certain extent, endogenous, especially when a sector is so big in a national economy that its performance affects directly, or at least leads to changes in, overall market wage rates and exchange rates. This is possible in a small economy with a shallow foreign exchange market which can be easily affected by the performance of a few key sectors.

4.5 The Perverse Effects of Macro Conditions

The role of macro-variables, such as wage rates and exchange rates, needs some final considerations. While low wage rates in emerging countries are considered as providing an initial window for ‘learning by doing’ in foreign or locally owned production facilities, they can also be a factor of decline because wage rates tend to rise eventually with a country success and the expansion of industrial production. The same logic applies to exchange rates. Some countries may want to maintain their exchange rates under-valued as an implicit
subsidy to boost exports. However, values of currencies are expected to appreciate eventually if a country succeeds in exporting and thereby records trade surpluses. So, longer term changes in macro-variables can be a factor for both rise and decline of an industry in a country.

For instance, consider the case of the Japanese Yen that went into a long term process of rapid appreciation in general, and in particular with respect to the Koran Won. This served as a critical factor in the rise of Korean industries and in the fall of Japanese industry. The Yen-dollar exchange rates was 227 dollars per Yen in 1980 but it dropped to 128 in 1988 (after the Plaza accord) and below 100 in 1995. In terms of the relative rates between the Korean Won and Japanese Yen, one Yen was equal to 2.7 Won in 1980, but it became 5.8 Won in 1988, and then 7.4 Won in 1996, and 10 Won in 2000. It is no wonder that Korea recorded trade surplus in the late 1980s for the first time since its post-war independence, and rapidly caught up with Japan since that time on and more so in the 1990s (Jung and Lee, 2010). On the hand, now the rapid increase in the wage rates in Korea can be a factor of possible future decline of Korean industries and of catching up by other latecomer countries, such as China. For instance, the rapid rise of wage rates in Korea might give an opportunity for Japan to strike a re-balancing in market-shares as the level of wage rates in two countries are now equal in the 2000s.

The above discussion indicates that while new technologies and changes in demand often offer opportunities for latecomers to replace existing leaders, macro-variables can be one the sources for both the rise and the decline for the same country.

5. **Summary and Concluding Remarks**

This paper has taken a long run view of the evolution of industries and successive catch-up by the late entrants. In order to explain the factors at the base of catch-up cycles and of changing leaderships in industry, it proposes to add a new explanation that would complement the existing ones. This paper proposes to take a sectoral system view and, within

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13 Data source from World Bank-WDI (World Development Indicator) DB.
14 For instance, the wage rates of Malaysia were about 70% of Korea in 1981. However, as the Korean rates rose rapidly, it became 29% in 1990, and then 25% in 2000. Also, in the mid 1990s, the Korean wage rates was less than half of Japan, but it kept increasing in the 2000s to reach 74% in 2004 and within the range of 90 to 110 % in the late 2000s. (source: ILO and World Bank/WDI)
that framework, to identify windows of opportunity that may emerge during the long run evolution of a sectoral system. Three windows related to the specific dimensions of a sectoral system are proposed: one related to changes in knowledge and technology, the second to changes in demand and the third to changes in institutions and public policy. It is therefore the combination of the opening of a window (technological, demand or institutional/policy), the presence of capabilities and the appropriateness of responses/strategies by actors that determines the successful catch-up by latecomer firms with favorable initial conditions.

As the preceding analysis has shown, sectors differ according to the type of windows that most frequently may open up and to the pattern of changes in market shares among key players. If one looks at technology windows, one notices that radical or disruptive innovations may serve as a window of opportunity for reaching soon industrial leadership for late entrants when these innovations are introduced by capable actors with forward-looking or leapfrogging strategies and supported by government policies. In contrast, cases of continuation in incumbent dominance may be related to the nature of innovations of the competence-enhancing type. A source of losing leadership is often associated with the concept of incumbent trap which implies an initial lukewarm response (or even the lack of response) by incumbents to new technologies. Although it may appear rational in an ex-ante sense, such a response often becomes the seed for market disruption by risk-taking entrants. In sum, attitudes toward newly emerging technologies by incumbents and late entrants are quite critical in determining catching up and changes in leadership.

As far as demand windows are concerned, the catch-up that may emerge may not result in a clear shift in leadership but only in a rise of new late comers that share the leadership with the old incumbents. In these cases, one may end up observing the coexistence of old and new firms from different countries. In fact the old demand does not disappear, and provides the support for the survival of the old leaders. Finally, government window acts favorably in support for a catch-up in two cases. One is in the early stages of a catch-up cycle by creating the conditions for learning and the accumulation of capabilities by new entrants in the industry. Here a gradual catch-up is set in motion by the government window. This is what most analyses of the role of a government window in terms of subsidies in favor of domestic firms, launch of R&D programs or protection of the home market have emphasized. The
second case is the public supporting to already capable domestic actors when another window, be of a technology type or of a business cycle type, opens up. In this case domestic actors may even leapfrog.

In sum, this paper has opened a way to examine catch-up cycles by viewing them as part of drastic changes in sectoral systems during their long-term evolution. It has proposed a framework that needs to be made more robust and more articulated. In particular, three lines of further research can be envisaged. The first one is the identification of the potentials for the opening of a window by looking at the specific features of a sectoral system and at the coevolution of its various elements. Some changes in technology, demand and policy may strengthen existing leader (as in the case of competence enhancing technical change) while others can open up real windows for catch-up (as in the case of disruptive innovations or totally new demand). The second line of research is the analysis of the degree of endogeneity that a window has with respect to the state of a sectoral system. The theoretical framework proposed in section 2, for the sake of simplicity, has considered windows as occurring at certain moments of the evolution of a sectoral system. But windows can be created by the very actors within the sectoral system that at a certain moment aim to introduce drastic changes, such as R&D investments by the latecomers in completely new technologies, and public policy as the result of a lobby of the latecomer companies. Finally, a third line of analysis concerns a finer grained analysis of the co-evolution between windows, capabilities and firms strategies for catching up.
Figure 1 Stages in Industry Catch-Up Cycles

Sources: Drawn by the authors.
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