Middle Innovation Trap

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Abstract

The middle income trap requires strategies for building technological capabilities to overcome it. This study focuses on the development patterns of two types of technological capabilities: implementation and concept design. A conceptual approach developed from evolutionary economics and innovation systems literature is constructed to distinguish between the types of technological capabilities and how they develop. The approach is mainly applied to the cases of Korea's development and it highlights the differences in developing implementation and concept design capabilities.

The findings of the study emphasize the need for the development of concept design capabilities, which requires (i) setting challenging targets, (ii) developing human resources, infrastructure and knowledge accumulation, and (iii) using an incremental process of trial-and-error and course correction. More broadly, sociocultural institutions may need to be changed to accommodate higher risk-taking but also require different approaches to change. The study extends the concept of technological capabilities by emphasizing the concept design capability that requires trial-and-error beyond R&D activities.

Keywords: middle income trap; middle innovation trap; technological capability; implementation capability; concept design capability

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Even as China's growth rate has slowed to the single digits, the concept of the middle income trap has garnered renewed interest in development policy circles. According to the World Bank [*World Bank,* 2012], among the 101 countries that have passed the lower threshold of the middle income in the 1960s, all but thirteen of these countries failed to surpass the upper threshold of middle income. It has become a recognized fact that economic growth slows down in the mid-income range for most countries [*Eichengreen et al.,* 2013] and the term "middle income trap" was coined to describe this phenomenon [*Gill, Kharas,* 2007].

The standard explanation focuses on a Lewis-type development model [*Lewis,* 1954]: at the first stage of economic development, underutilized, low-cost labor that is locked in the less productive agricultural sector moves towards the more productive manufacturing sector. At the same time, the simple adoption of foreign technology and facilities and efficient operation based upon imported, codified knowledge (e.g., manuals) increase the cost competitiveness of the product on the export market [*Radosevic,* 1999]. Hence, the so-called latecomer's advantage emerges [*Gerchenkron,* 1962]. However, as the economy reaches middle income, the latecomer's advantage disappears and competitors equipped with lower labor cost and more up-to-date technology and facilities diminish rents, which slows growth. Thus, we observe the country locked in the middle income trap [*Agenor,* 2017; *Kang et al.,* 2015; *Vivarelli,* 2016]. While this argument logically explains the steps leading to the middle income trap, we cannot determine how to escape.

This paper considers the development patterns of two types of technological capabilities to explain the source of the middle income trap and strategies to overcome it. The following section describes the middle income trap as the failure to transform the potential of introducing technological capabilities into the potential for individual design. We then discuss the differences between the two technological capabilities and explain the evolutionary process of accumulating design capability. We compare a coherent innovation system supporting implementation capability and design capability, respectively. After this, we show three different ways to accumulate experience for creative trial and error based on case studies: time, space, and policy for the cases of advanced countries such as China and Korea. Finally, we introduce the concept the innovation commons as well as the four pillars of design capability: advanced manufacturing base, strong learning capability, cultural appreciation of trial and error, and consistent innovation policy. The last section summarizes the main arguments of the paper and directions for further research.

The Source of the Middle Income Trap from the Perspective of Innovation Capability

Any proposal for products and services requires capabilities to actualize them: (i) design capability to define the specifications and functions of the product or service and (ii) implementation capability to physically engineer the design to deliver them. Increased vertical specialization has led to a division of labor between developed countries and developing countries [*Hummels et al.,* 2001] determined by implementation and design capabilities along global value chains [*Dedrick et al.,* 2010; *Gereffi et al.,* 2005].

The typical process for economic development based on these two technological capabilities can be described as follows: a developing country starts its economic development with implementation capability to manufacture products based on the concept designs imported from advanced countries. When the country succeeds, it is expected to reach the lower boundary of the middle income level. As the country enhances its implementation capability and starts to successfully perform concept design, it will reach the upper threshold of the middle income level. If the country accumulates sufficient design capability, it will become a high-income country. This explanation is quite consistent with previous studies [*Bell, Pavitt,* 1993; *Kim,* 1997; *Lall,* 2000; *Radosevic,* 1999]. Figure 1 depicts the typical stages of economic development according to the development of capabilities.

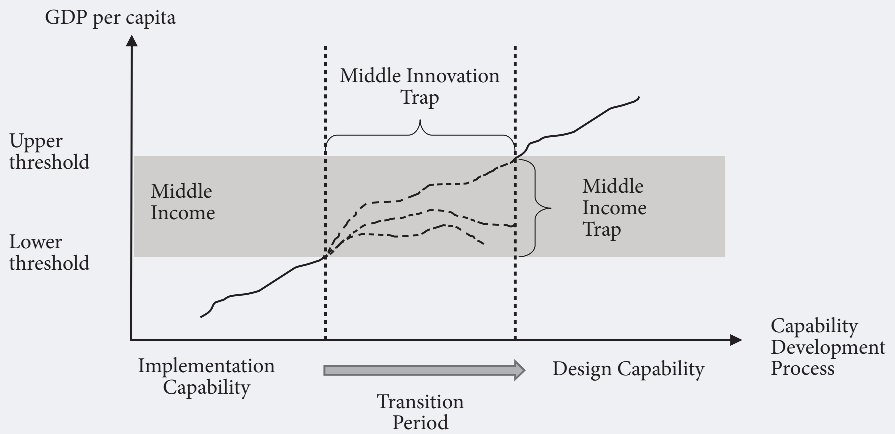
Recent studies argue that technological capabilities are necessary to avoid the middle-income trap [*Agenor,* 2017; *Kang et al.,* 2015; *Lee,* 2015; *Vivarelli,* 2016]. A large number of developing countries reach the lower boundary of middle income without difficulty, but most developing countries fail to achieve high income. The difficulty in crossing the threshold of high income implies a difficulty in securing concept design capacity despite of accumulating implementation capability. Thus, concept design capacity may be considered a condition for overcoming the middle income trap and to becoming a high income country. In this sense the *middle income trap* can be alternatively named as the *middle innovation trap* or *capability transition trap* since the failure to transition from implementation to design-based capability is the fundamental reason for the trap.

Characteristics of Implementation and Design Capabilities

The Difference between Implementation and Concept Design Capabilities

If we consider the construction of a skyscraper, a company with concept design capability will draft architectural designs and another company with implementation capability can realize the architectural

Figure 1. **Stylized Development Process Based on the Transition of Innovation Capabilities**



Source: authors.

plans by gathering the necessary resources within a schedule given by the design team. Design and implementation capabilities[1] can be recognized separately in every product and service we utilize ranging from buildings and sneakers to automobiles, microprocessors, and even movie and entertainment programs.

Moreover, we find similar combinations of concept design and implementation capabilities across all products. In the case of architectural design, basic design is made by an architecture company while an engineering company makes a detailed design by interpreting the concept illustrated in the basic design, i.e., implementation. The Just-in-Time System is an example of design in the production process. While Toyota conceived it, the process has been implemented by automobile companies around the world.

In this respect, global champions create concept designs and other companies interpret and implement them. A country with a large number of companies that generate concept designs are by definition a technological leader. In terms of the division of labor, companies in advanced countries generally have concept design capabilities and those in developing countries possess implementation capabilities.[2]

The two capabilities are different mainly in four aspects: mode of expression, strategy to nurture, performance criteria, and learning curve and cost. Table 1 summarizes the key features of the two.

Implementation capabilities refer to the ability to realize a given concept design. Knowledge used by implementation is expressed mostly in explicit forms such as manuals [*Bell, Pavitt,* 1993] and, therefore, is easier to transfer [*Cowan et al.,* 2000]. Efficiency in terms of speed and cost is the performance measure and repetitive execution reduces the time and cost through learning-by-doing [*Zollo, Winter,* 2002]. The time and cost to acquire such experience is not high, so developing countries can learn implementation capabilities through the transfer of explicit knowledge and training in a relatively short time period. Thus, we can often observe the case that a successful developing country masters the implementation capability and even improves it by achieving higher implementation efficiency through its own efforts.

On the other hand, the ability to create a new concept design is often expressed in tacit forms such as the accumulated experience of professionals and a form of organizational memory. The criterion for performance is the uniqueness of the products and services. Creative and novel concept designs can only be obtained by accumulating experience through trial and error [*Zollo, Winter,* 2002], through learning-by-building. Due to its tacit nature and the accumulation effect, it is relatively difficult for developing countries to assimilate this design capability from developed countries [*Cowan et al.,* 2000], which makes design a core competitive advantage for high-income countries.

This paper also points out that the transition from implementation to concept design capability is not an automatic process [*Bell, Figueiredo,* 2011]. In other

[1] Dahlman et al. [*Dahlman et al.*, 1987] classifies technological capabilities into production, investment, and innovation capabilities. Investment capabilities are further typified by management and engineering characteristics, which relate to production and innovation aspects of the technological capabilities. In this paper, investment capabilities are separated and connected to production/implementation and innovation/design.

[2] Using the case studies of companies during the development stages of Korea, Kim [*Kim,* 1997] highlights the difference between imitation and innovation capabilities. He shows that developing countries in general start their economic development by imitating product technology from advanced countries before moving to the innovation stage. While Kim refers to imitation as the copy of products produced in the advanced countries, implementation in this paper indicates the realization of designs developed by companies in advanced countries. The OEM (Original Equipment Manufacturing) model based on the design concept of advanced countries, which has been the prevalent mode of production in developing countries, emphasizes the importance of implementation, not imitation, as the key competency for developing countries.

Table 1. **Key Characteristics of Implementation and Design Capabilities**

Key aspects	Implementation capability	Design capability
Mode of expression	Explicit	Tacit
Performance criteria	Efficiency	Differentiation
Strategy to nurture	Learning-by-doing with accumulation of repetitive execution	Learning-by-building with accumulation of trial and error
Time and cost for learning	Low to medium	Medium to high
Source: authors.		

words, mastering implementation does not necessarily lead to accessing concept design capability[3] and can lead to the lock-in of an inferior technology [*Jovanovic, Nyarko,* 1996]. This argument is supported mainly by the observation of the middle income trap, where most developing countries fail to achieve high income even with the successful acquisition of implementation capability. The theoretical reason for this capability transition failure will be detailed in later sections.

Evolutionary Accumulation Process of Design Capability

Concept design is fundamentally different from implementation, mainly because the former is the outcome of the accumulation of creative trial and error experience. The development process of building up design capability clearly demonstrates this. In order to create a novel concept design, first, we need a challenging vision [*Augier, Teece,* 2008; *Martin,* 1995; *Pietrobelli, Puppato,* 2015]. Novelty can be defined in many terms, such as higher quality, unique functionality, and a new dimension of utility. Second, we need an innovation network in order to leverage other actors' accumulated experience, which may take the form of learning, transfer, employment, contract, or strategic alliances [*Almeida, Phene,* 2004; *Bell, Pavitt,* 1993; *De Marchi et al.*, 2015]. Third and most important, there should be the accumulation of trial and error by piloting, evaluating, selecting, and recombining alternative designs [*Thomke et al.*, 1998]. While concept design capabilities are critical to innovation, they are not solely dependent on R&D activity [*Hirsch-Kreinsen et al.,* 2006]. The selection can be made based upon internal criteria of the company and/or external criteria of market, societal, and public policy considerations [*De Marchi et al.*, 2015].

A challenging vision, innovation network, and accumulation of trial and error experience are highly evolutionary,[4] as much as is exploring the unknown peak of a mountain: (i) setting the target, (ii) utilizing local human capital, establishing infrastructure, and experiencing previous attempts, and (iii) climbing up step-by-step while checking and accumulating the acquired information during a trial and error process and subsequently correcting the route. Thus, the process of finding a new concept design is a typical process of exploration by trial and error dependent upon technological complexity [*Thomke et al.,* 1998; *Frenken,* 2006].

The three components reinforce each other over time to create a positive feedback loop, a so-called scale-up process. When a new design (D1) is made, we can accumulate all the trial and error experience (T1) behind the resulting design (D1) with outside information through networking (N1). This accumulated experience will constitute the key resources for reaching the next stage of design (D2=D1+T1+N2) with information added through networking (N2). The accumulated experience (T1) will also spillover to other actors in the country for making their own design. Thus, a company that experiences successful design and trial and error can set a more challenging vision for itself, it can form a wider network with higher capabilities, and most importantly, it can tolerate longer periods of accumulation of experience, which helps the company build up higher levels of concept design capability. This typical evolutionary process with positive feedback renders a wider gap between developed and developing countries over time, and thus, we observe the middle income trap.

[3] Lall [*Lall,* 2000] emphasized the difference between the concepts of 'know-how' and 'know-why,' which correspond to the implementation and design capabilities in this paper. His main argument is, even though know-how can be obtained through learning, it does not lead to the 'know-why' of the system because it is governed by a different knowledge dimension.

[4] The three components correspond collectively to the traditional components of the evolutionary process: variation (V), selection (S), and retention (R) [*Dosi, Nelson,* 2010]. For the first component, with a more challenging vision, we propose more diverse ideas (V) and we can select more unique alternatives (S). For the second component, we can conjecture that wider networking renders more diverse combinations (V) and let more distant actors have a chance to retain accumulated experiences (R). For the last component, more consistent and systematic accumulation of trial and error experience over longer periods affects the quality and quantity of retention (R), but at the same time, has positive feedback for variation (V) and selection (S). The above discussion implies that the suggested evolutionary components of design development accommodate theoretical rationales for evolutionary economics. Moreover they reflect micro-routines of design capability we can observe on a daily basis at the company level and further are more intuitive.

The Characteristics of Innovation Systems Based upon Implementation and Concept Design Capabilities

Sets of Routines as Characteristics of Innovation Systems at the Company Level

A set of company routines will determine which problems it has to solve and which alternative solutions it will test, evaluate, and select. Thus, it forms a paradigm and framework for decision-making for all production/innovation processes. An important point of the main theme of this paper is that the sets of routines are different according to the core capabilities and whether they are based upon implementation or design. It can also be a reflection of the innovation system at the company level, which implies that an innovation system based on implementation capability would be different from that based on design. In order to evaluate the different parts of company routines, the following four aspects should be verified: (1) the objective of production/innovation, (2) performance evaluation and compensation system, (3) organizational structure and communication style, and (4) the attitude towards the trial and error.

When the performance of a company is based upon implementation capability, it sets efficiency in terms of time and cost as the objective of production/innovation [*Lee et al.,* 2004]. Performance evaluation and compensation will be determined by short-term and tangible measures of output. Organizational structures with silos that have a strict division of work processes and hierarchical communication structures are established, which contribute to faster implementation. Most importantly, the company will try to minimize trial and error since efficiency is the goal.

On the other hand, when a company bases its core capability on proposing new concept designs, experimentation leads to greater variation [*Lee et al.,* 2004]. Performance evaluation and compensation criteria are based upon longer term and intangible outcomes while autonomy and recognition among peer professionals are considered more important incentives than monetary reward. A horizontal communication structure and network-like organizational structure are preferred in order to increase the probability of unexpected combinations and serendipitous discovery. Trial and error is encouraged and routines emerge to systematically retain organizational experiences.

The above arguments imply that the set of routines of a company creates a coherent innovation system that lets certain types of activities prevail. Companies in developing countries generally have sets of routines supporting implementation capability, and it therefore becomes more difficult to transition to a set of routines based on concept design capability as they achieve greater success based on efficiency. This constitutes a typical example of lock-in and path dependency in the innovation system [*Dosi, Nelson,* 2010]. In other words, in a successful developing country, a young entrant, who is not locked into implementation routines, is more likely to acquire design competencies than are successful incumbents who are skilled at implementation.

Characteristics of National Innovation Systems according to Different Core Capabilities

A national innovation system is a collection of institutions that regulate the generation, diffusion, and utilization of knowledge between firms and other actors [*Lundvall,* 1992; *Amable,* 2000] describes it as a coherent system that consists of systems in finance, education, knowledge, trade, socio-political institutions, and industry (vertical/horizontal), while it depends upon macroeconomic conditions and innovation policy with firm competencies and strategy at its core. Figure 2 depicts the schematic relationship among such systems.

For a developed country, the characteristic features of a national innovation system are harmonized and reinforce design capability. An example of this is an education system that focuses on creativity and hands-on experience, a well-developed venture capital system for supporting entrepreneurial trial and error, a well-developed professional track system, and a well-functioning M&A market to promote novel combinations. Even though there are different types of coherent innovation systems depending upon historical, geographical, and cultural characteristics, all share a commonality that supports a challenging vision, an innovation network, and the accumulation of trial and error to nurture further design capability.

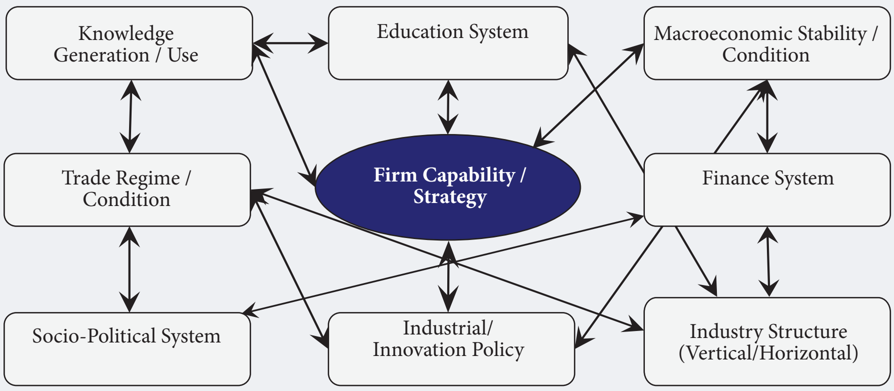
The Case of Korea as an Implementation Capability-Based Innovation System

The history of Korean economic development shows that the features of the national innovation system are closely linked to form a coherent system. When the Korean economy reached the middle income level, it was characterized by its efficient implementation capability.

Each feature of the innovation system is closely intertwined to reinforce one another.[5] For example, in order to secure enough workers for the industrial development in a relatively short period of time, the government invested heavily in education focusing on elementary and secondary school together with a strong emphasis on vocational education. The main educational goals also focused on basic literacy skills, math, and ethics for industrial society (*an education system to support industrial activities*). The six heavy and chemical industries of steel, petrochemical, automobile, electronics, shipbuilding, and machinery,

[5] The characteristic features of the national innovation system of Korea from 1960s to 1990s can be found in [*Kim, Dahlman,*1992; *Kim,* 1997; *Lee,* 2005; *Lee,* 2015].

Figure 2. **National Production/Innovation System as a Coherent Institutional Arrangement**



Source: authors.

which were all capital-intensive and technologically mature, were selected in order to minimize trial and error and maximize the learning-by-doing effect which focuses upon efficient execution and operation (*concentration on capital intensive and mature industries*). Large business conglomerates (*chaebols*) were promoted to maximize the effect based on economies of scale and scope (*large enterprises dominating the industry structure*), and a bank-backed financial system supported their heightened investment demand (*credit-based finance system*). The government intervened explicitly in the industrial structure through resource allocation (*explicit industrial policy*) with the private sector actively involved in planning and monitoring *(public-private partnership in all policy domains*). An export focus was the most important performance criteria in all the national level decision making for industrial development (*export focus*). The knowledge sector of public research institutes and universities focuses not on creating a new inventive technology, but on interpreting and disseminating the foreign technology into local enterprises with negligible absorption capacity (an *assimilation- and diffusion-based technology strategy*).

All the above characteristics, ranging from education and finance to trade regime and industrial policy, collectively reinforced the implementation capability up to 2000. As Nelson [*Nelson,* 1993] demonstrated, a large number of countries with middle income share a similar coherent system for implementation capability even though the portfolio of the components in a system may vary across countries depending on their historical and cultural backgrounds.

Lock-in Hindering the Transition from an Implementation- to Design-Based Innovation System

Once the institutional arrangement is set based on implementation capability, the incentive system encourages activities to reinforce implementation. Thus, entrepreneurial challenges that necessarily entail trial and error would not be favored, which pushes human resources into sectors that focus on efficient implementation over concept design. This creates a trap where human resources are unavailable, concept design capability erodes, uncompetitive companies focus on design, which negatively affects companies' abilities to attract capable human resources, and companies are more strongly locked into implementation routines.[6] This is why we see most middle income countries fail to move up the ladder.

Since the early 1960s, Thailand has pursued an import substitution strategy using CKD (Complete Knock-Down)-style OEM (Original Equipment Manufacturing) strategies in the automobile industry, focusing on the assembly of imported parts and components while quickly establishing an industrial base on the foundation of imported facilities and manuals focusing on efficient operation. Further, the Thai government established an automobile cluster to minimize transport costs and provided fiscal and institutional incentives to attract MNCs (multi-national companies). The government also supported training for the assembly line and provided incentives for export activities. On the market, policy encourages efficiency-enhancing competition in the lower tiers of the automobile industry, where indigenous firms are found. As a result, Thailand emerged rapidly as

[6] Agenor and Canuto [*Agenor, Canuto,* 2012] provide a neoclassical growth model accommodating the concept of the design sector and the incentive effect. This argument concerning vicious cycles focusing on implementation is based on Agenor and Canuto's analysis of the low equilibrium state.

an Asian automobile production and export hub for major MNCs with minimal losses. Therefore, the automobile sector contributes to a large share in terms of GDP and employment, which may be considered the main benefit of a rapid implementation strategy.

Unfortunately, this system of locked-in implementation hinders trial and error activities and the creation of institutions that are prerequisites for innovation. Learning institutions such as research organizations and universities have a limited focus on the industry and are new enough to lack doctorate programs, which impedes the acquisition of trial and error experience. Domestic individuals, firms, and other actors are less capable of generating designs in every segment of the industry ranging from design, production, parts and components, and marketing. All carmakers in the Thai economy are subsidiaries of MNCs, who in turn also enjoy most of the rents. Meanwhile, local parts and components suppliers in the sector are left with a small share, which leads to low added value and profitability. Worse than that, important variables, such as production volume, the product portfolio, export market strategy, and even employment depend critically upon the managerial decisions made by MNCs headquartered outside Thailand. Occasionally the Thai government sets policy initiatives to improve the capabilities of the automobile industry without appreciable progress.

Moving from implementation to concept design in an innovation system is difficult because all the components of the innovation system surrounding implementation must change simultaneously. Moreover, the components of innovation should change according to the development stages and changes in the external business environments [*Matthews,* 2002]. In short, the coevolution of a coherent system is required for the transformation of an innovation system [*Geels,* 2005]. However, once a specific type of coherent innovation system is organized, vested interests emerge that obstruct change. Thus, we observe a large number of countries that have succeeded in obtaining implementation capability trapped in the middle income trap because most fail to coevolve of all the components that are locked into implementation alone.

Three Strategic Tools to Accumulate Trial and Error Experience: Time, Space, and Policy

The accumulation of trial and error experience is the critical prerequisite for creative design, since a new design by definition is an unknown artifact that can be made or found only through exploration. If we take the new generation of microprocessor chips as an example, there must be numerous attempts, evaluations, selection, and retesting of different combinations of new materials, new architectural structures, new programming logic, and new assembly equipment, to name a few.

Advanced countries, which enjoy high income levels and lead industrial development with their own designs, have accumulated trial and error through the efforts of private entrepreneurs, researchers, and organizations and have designed new concepts since at least the Industrial Revolution in the 18th century. They gained these experiences not only within corporations but from general society. As this experience accumulated, more challenging targets were set which allowed the depth and breadth of innovation network to evolve further. Therefore, *time* was the main factor behind advanced economies accumulating trial and error.

There are few developing countries that escaped the middle income trap by gaining concept design capabilities. Among them, Korea provides a good example of a country with a population of 50 million that started its development process without natural resources and emerged from the ruin of a colonial period (1910–1945) and the Korean War (1950–1953). Within five decades Korea managed to overcome the middle income trap based on key designs in targeted high tech sectors.

Korea began its economic development in the mid-1960s with a GDP per capita level of less than USD 1,000 and reached middle income status in the mid-1980s. Implementation capability improved during the 1960s through the 1980s and contributed to cost competitiveness on the international export market and a coherent policy framework that supported the efficiency-based implementation capabilities of the private sector. From the mid-1980s, Korea began to run the virtuous cycle and obtained concept design capacities in key sectors. The efforts finally paid off as world-class designs were developed in targeted high tech sectors from the early 1990s, which included next-generation DRAM chips, display technologies, new automobile engines, LNG (liquefied natural gas) carrier ships, and others. With the advent of domestically-generated concept designs, the export product portfolio changed dramatically in a short period of time.[7] We can find some common factors behind the buildup of concept design capability [*Kim,* 1997; *Lee, Baek,* 2012]. First, visionary target setting was carried out based on a public-private partnership. Second, global networking was pursued aggressively with an experienced knowledge hub through various activities such as licensing, recruiting, and co-development. Third, trial and error experience was accumulated based on a wide and diverse set of export markets and leadership in both the public and private sectors that support the risk associated with challenging trials that have a long term perspective.

One case that clearly illustrates the three factors is the commercial development of the mobile commu-

[7] The main export items in the early 1970s were fisheries and agricultural products, textiles, plywood, footwear, and other low value added manufacturing products, but from the mid-1990s, they became semiconductor, displays, automobile, petro-chemical products, high value added ships, and so forth.

nication technology CDMA (Code-Division Multiple Access) by Korean stakeholders. First, public and private sector actors reached consensus on a bold target (challenging vision) to commercialize mobile communication technology in 1989. The technological jump was daunting considering Korea lacked a national telephony infrastructure as late as the preceding decade. Second, Korea formed a network with Qualcomm in the US to access key intellectual property that led to co-development through licensing (innovation network). Third, it took more than seven years of trial and error to finally arrive at a design (the accumulation of experience). It provided a technology platform for USD 27 billion worth of mobile phone exports in 2015 according to the trade statistics.

Unlike advanced countries, Korea lacked absolute time to accumulate trial and error. However, the above cases demonstrate that policy can compress the time required for accumulation and securing design capability.

China, on the other hand, provides an alternative model, given that recently it started to generate its own concept designs in the field of complex system sectors such as high-speed trains, power generation and transmission technologies, consumer electronic products like mobile phones, and new business models such as e-payment systems. Like Korea, China lacked absolute time to accumulate trial and error, but it accelerated the accumulation process using the size of its market. A large number of visionary entrepreneurs created concept designs in different niches of the market, which implies the absolute amount of trial and error in a given time period was larger than those of any other country. Moreover, the Chinese government, through the purchasing power of SOEs (state-owned enterprises) for example, shares the risk of trial and error. Foreign companies transfer their accumulated experience voluntarily or involuntarily in order to access the Chinese domestic market, which helps improve the innovation network.[8] Moreover, the export market, which is dominated by Chinese products played the role of a platform to accumulate the aforementioned experience by exposing domestic entrepreneurs to diverse market needs. Exports provided the opportunity to accumulate trial and error while creating new product demand on the world market. With all these observations in mind, we know that *space*, which is the size of the market for the case of China, is another strategic way to accumulate capacities for nurturing design capability.

In the case of Korea, developing design capability in some high tech sectors provides important lessons for developing countries in the middle income trap because time and space are resources that are not transferable. A strategy that uses a policy platform focusing on the components of an evolutionary process for design — a challenging vision, innovation network, and accumulation of trial and error — provides the means for operating within a restricted timeframe and space.

The Erosion of Concept Design Capability: Current Challenges for Korean Industry

The term “middle innovation trap” implies that without a concept design capacity, a country cannot overcome the middle income trap. In other words, concept design capability is sufficient for ensuring a move to high-income status. However, concept design capacity may decrease if the components of the evolutionary process for design, including challenging vision, innovation network, or the accumulation of trial and error, become weak, which may result in low profitability and ultimately a slowdown in growth.

Korea is known as one of the benchmark cases in that it overcame the middle income trap based on its own concept design capabilities in some high tech sectors. Evidence that supports the above argument include the new products in the mobile, automobile, display, and shipbuilding industries as well as the new global companies that produced the concept designs of the new products, at least up to the mid-2000s, when it surpassed a GDP per capita level of 20,000 USD.

However, since the mid-2000s, there have not been any new major entrants and the top export items have not changed, which signifies the slower speed of industry dynamics.[9] For the last decade at least, the profitability of the manufacturing sector and overall investment rate have steadily declined, and accordingly, we are observing a gradually decreasing GDP growth rate. Some analysts are concerned about the possibility of Korea entering a prolonged structural depression similar to what Japan endured over the last two decades.

In the current Korean industrial landscape, quite a few global companies, such as Samsung, Hyundai, and LG, which already command their own concept design capabilities in some product categories are mixed with a large number of companies that are still locked into the implementation processes. A few global companies tried to upgrade their concept design by strengthening their network with global knowledge sources, such as technology-based companies located in Silicon Valley. Moreover, they may relocate their manufacturing sites according to the change of global business environments. With these observations in mind, we understand that the link in terms of production/innovation activities among

[8] China has maintained a 50:50 ownership structure for FDI companies, which contributed greatly to the spillover effects from foreign to domestic companies [*Felipe, Rhee,* 2015].

[9] For the case of advanced countries after 2000, there have been new and innovative entrants appearing and changing the industry landscape in terms of the ranking of companies, which makes a sharp contrast with the Korean situation.

these global companies and local actors have weakened over time. Thus, the links between exports and the local economy, therefore GDP growth and local employment, are lost.

The gap between global companies and local actors in terms of innovation capacity has been the shadow of a successful industrial policy up to the 1990s. In order to amass resources to sustain trial and error for concept design capability, the government had to select a few actors as national champions and concentrate resources there with institutional support. Most of the other companies were left with limited resources to gain experience and, as a result, remained solely within the implementation category. On average, many aspects of the national level institutional framework still hinge on implementation capability, leaving industry largely incapable of innovation. For example, the entrepreneurial activity of startups is limited and venture capital to share the risk of entrepreneurial trial and error is not well developed. There are cultural features that reinforce the framework for implementation capability. The education system still depends on unilateral teaching based on memorization and few career development paths exist to nurture specialists rather than generalists. In industry, a silo mentality, which was effective for efficient implementation, remains strong with hierarchical communication structures, while vertical industry relationships leave room for improvement in terms of the fair distribution of mutual benefits. Thus, we observe that Korea seems to have overcome the middle income trap with the help of concept designs developed by a few global companies, yet it may still be in the middle innovation trap at the national level.

The following figure shows the relationship between GDP per capita and IPR (intellectual property rights) net exports per capita across 88 countries with available data from the World Development Indicators published in 2014 by the World Bank. The sample excludes countries with a population of less than a million, small land mass, and natural resource-based countries. We observe a half U-shape curve that implies that as a country starts to develop, it imports design and architecture from advanced countries (the downward sloping part of the curve), but later IPR performance improves (the upward sloping part of the curve) as design capability increases. Despite being classified as a rich country, Korea (represented by the red line) seems to deviate from the stylized pattern of the U-shape, which indicates that it may be trapped in implementation capability and thus, in the middle innovation trap as we discussed in the previous section.

All these characteristics that are still focused on implementation capability will eventually have a detrimental effect upon the concept design capability, a risk that few global companies face since they are also part of the innovation system. Therefore, it is highly necessary to narrow the gap in terms of innovation capabilities among Korean companies and set a national policy framework to nurture concept design capability.

Innovation Commons as a Platform for Design Capacity

Securing design capability requires simultaneous changes of all institutional arrangements of the national innovation system ranging from education, finance, industry structure, trade regime to industry and innovation policy, that is, it involves the coevolution of a coherent system. This also demands concerted changes for all actors, which is difficult given that the incentive schemes do not always match. In order to facilitate concomitant actions of the individual actors, we need the concept of an *innovation commons* as a platform with tangible and intangible parts to mobilize these actions. Specifically we have to define an innovation commons for design capability, which contributes to nurturing the key components of the evolutionary process of design: challenging vision setting, networking, and accumulating trial and error.[10] Based on innovation system theory and a stylized evolutionary process of innovation, the following four factors should be included: (1) a strong advanced manufacturing base, (2) a learning capacity to nurture professionalism, (3) socio-cultural institutions to favor the accumulation of trial and error experience, and (4) consistent innovation policy to lead to change.

A Strong Advanced Manufacturing Capacity as a Platform for Trial and Error

An advanced manufacturing plant is a good job creator, but more importantly it provides a physical platform to test prototype designs. Japan is well-known for its strong manufacturing capability, which allows the economy to maintain competitiveness even during a prolonged depression.[11] It is a fact that the speed and quality of building new concept designs improve greatly when innovation and production sites are located nearby [*Nahm, Steinfeld,* 2014].

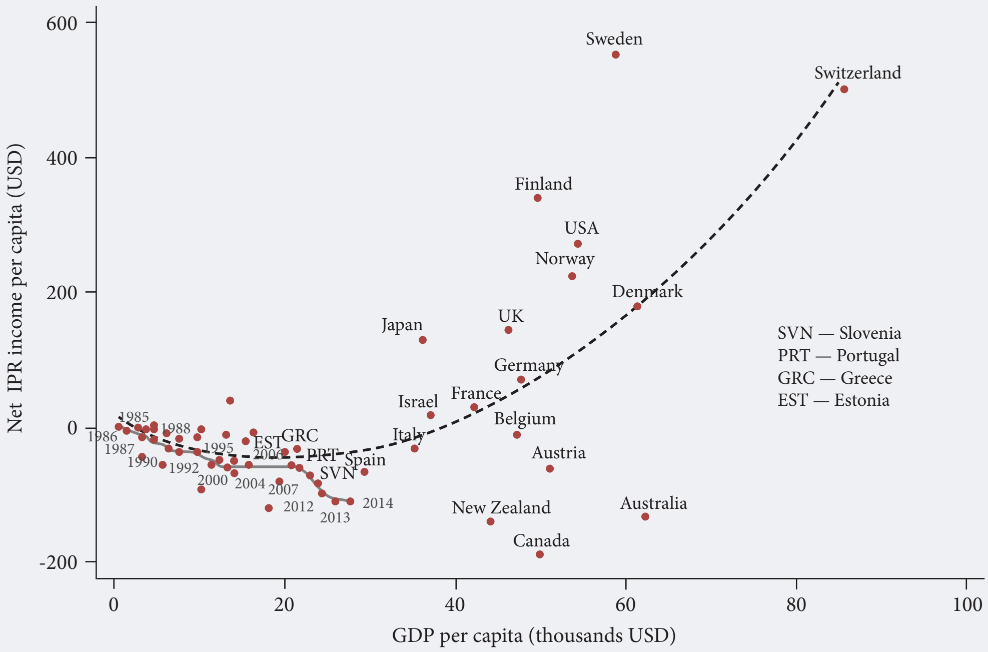
Learning Capacity to Nurture Professionals

Concept design capability ultimately resides in the memory of professionals and as an organizational routine. Professionals with learning capacity welcome new ideas and feel comfortable entering new fields. There-

[10] Pisano and Shih [*Pisano, Shih,* 2012] suggest the concept of an industrial commons to support production and innovation activities for the rebound of the US economy. They specified an advanced manufacturing base as the single most important industrial commons. Here innovation commons as an extended concept of industrial commons are suggested to cover tangible and intangible factors, such as culture and attitudes towards experimentation and creativity.

[11] The sources of Japanese manufacturing capabilities can be found in [*Fujimoto,* 1999].

Figure 3. **Relationship between Economic Performance and Net IPR Income by Country, 2014**



Source: authors based on [World Bank, 2014].

fore, this ability to learn should be one of the most important common fields from which every actor can benefit.[12] However, individual companies may not be able to appropriate all returns from an investment to nurture professionals due to job turnover and thus, this requires public intervention. In order to promote learning capability, we need first to establish career development paths for professionals with accumulated trial and error experience over a long period of time. Second, the absolute amount and relative share of labor compensation should be increased, which, in turn, would increase the investment to voluntarily commit oneself to life-long learning.

Socio-Cultural Institutions to Favor the Accumulation of Trial and Error

A society should have a socio-cultural environment that tolerates creativity and trial and error, mainly because new designs are the only outcome of accumulated learning. In contrast, when a country's economy is based on implementation capability, creativity ends up being something to minimize because socio-cultural institutions are set up to avoid error as much as possible. In order to realize a design-based socio-cultural commons, we need to create a rational society open to every critical but constructive debate, because trial and error can only occur through active debate, not through strict hierarchy. Second, trust is the intangible basis for trial and error. Without trust, short-term tangible outputs would be used for performance criteria, and as a result, the mission to create novel designs would not survive, because they are associated with long term results and have a high probability of failure.[13]

Consistent and Coherent Innovation Policy to Lead Change

Innovation commons require active policy intervention mainly because as we can figure from the name commons, we can assume that the benefit of investing in the commons go beyond the boundary of individual actors. There is a long list of innovation policy tools, but three policy agendas are most relevant when considering the key components of an evolutionary process for concept design.[14] First, the role of the finance sector should be redefined to help industrial sectors. Recently the intrinsic role of finance to hedge the risk associated with challenging entrepreneurial trials has been weakened, especially after 2000 and more specifically after the global financial crisis in 2007.

[12] Stiglitz and Greenwald [*Stiglitz, Greenwald,* 2014] emphasized the important relationship between education and economic development. Mehta and Felipe [*Mehta, Felipe,* 2014] found a positive relationship between education and economic diversity.

[13] The relationship between trust and innovation was discussed in [*Dirks, Ferrin,* 2001]. Harrison and Hunttington [*Harrison, Hunttington,* 2000] and Rodrik et al. [*Rodrik et al.,* 2002] argue that institutional quality including the level of trust positively affects economic growth.

[14] Among others, we can find recent arguments for the active role of industrial and innovation policy in [*Mazzucato,* 2011; *Stiglitz et al.,* 2013].

Thus, there must be policy consensus on the appropriate role and responsibility of the finance sector to support trial and error. Second, public procurement can play an important role as a test bed for innovative concept designs. If it appeals to public interest, we have a good reason to spend taxpayer money even on expensive but innovative products. Third, research organizations including universities and public research institutes should be heavily supported for long term and risky projects. These are all policy tools to spread and share the risks associated with the design process.[15]

Conclusion and Avenues for Further Research

Summary of the Main Arguments

In order to create a new product or service, we need concept design capacity to define the task and implementation capabilities to realize the design. In general, companies in developed countries have the former and those in developing countries have the latter. A developing country starts its development process by acquiring the implementation know-how to reach the middle income level with relative ease. However, most countries fail to move beyond middle income, mainly because they cannot obtain concept design competencies as a pre-requisite for becoming high income countries.

The abilities based on implementation and concept design entail different sets of routines, which implies a different collection of characteristics of the innovation system. Implementation capacity focuses on higher efficiency based on learning-by-doing and aims at minimizing trial and error. On the contrary, concept design targets differentiation based on learning-by-building and accumulates experience through experimentation and creativity. Once the innovation system of a developing country is locked in on implementation, it then becomes more difficult to transform itself into a design-based innovation system. In this sense, the middle income trap can be alternatively called *the middle innovation trap* or *capability transition failure* that suggests the difficulty of crossing the chasm between two innovation capabilities.

The accumulation of creative trial and error is the most important part of developing design capability. Advanced countries have accumulated this experience since the Industrial Revolution in the 18th century, which means they performed trial and error over *time*. China, as an emerging industrial hub, is accumulating such experience based on the enormity of its domestic market, that is, through *space*. Korea, as one of the benchmark cases to successfully overcome the middle income trap, managed to compress both the time and space needed for improving creativity through coherent *strategy*, which provides interesting lessons for most developing countries in the middle income trap that do not possess vast reserves of time or space.

An innovation system based on implementation is different from that based on design, which implies that the transition requires concerted action among all actors in the innovation system. The concept of an innovation commons is useful as a set of tangible and intangible infrastructure to help frame change, specifically to promote creativity. Innovation commons consist of four factors: a strong advanced manufacturing base, learning capacity to nurture professionalism, socio-cultural institutions to favor the accumulation of trial and error experience, and consistent innovation policy to lead change. All are directed toward reinforcing the evolutionary process of design development.

The process to gain design capability is itself a long-term evolutionary process, which requires long-term and consistent policy commitment based on nationwide consensus. More importantly, the policy to lead change needs to be experimental and evolve based on creative experience.

List of Questions for Further Research

The arguments contained in this paper need theoretical and empirical support based on qualitative and quantitative data. The following are some of questions that await further research efforts:

Theme 1. Quantifying the two types of capabilities and the development patterns

- What would be the appropriate measure of implementation and concept design capabilities at a company and national level?
- Can we demonstrate and specify the development patterns of the two capabilities in terms of an evolutionary process?
- Can we identify the relationship between 'production' and 'innovation' from the perspective of the development patterns characterizing the two capabilities?
- Can we classify countries in terms of innovation capability development, and does it align with the economic development process?

Theme 2. Exploring the difficulty of capability transition and coherent innovation systems

- Can we interpret the stagnating growth performance of South American countries, East European countries, resource-abundant countries,

[15] Mazzucato [*Mazzucato,* 2011] emphasizes the importance of risk socialization, but at the same time she argues that the reward for innovation should also be socialized.

and emerging economies in terms of *the failure to transition from implementation to design or the middle innovation trap*?

- What are the critical factors that affect the speed of accumulating creative trial and error experience for new design?
- What is the taxonomy of industrial and innovation policy to help private companies build up design capacity? What is the rationale for policy intervention?
- Are there sectoral differences in terms of strategies employed to obtain design capabilities?

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