Middle Innovation Trap:
Transition Failure from Implementation Capability to Concept Design[1] Capability as a Source of the Middle Income Trap

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1. Introduction

The middle income trap has become an important keyword in the policy discussion regarding growth issues. According to the World Bank (2012), among the 101 countries that have passed the lower threshold of the middle income level since the 1960s, all but thirteen of these countries have failed to surpass the upper threshold of middle income. It has become a stylized fact that economic growth slows down in the middle income range for most countries, and the middle income trap or middle income country trap was coined to describe the phenomenon.

The standard explanation focuses on the latecomer's advantage: at the first stage of economic development, underutilized, low-cost labor that is locked in the lower productive agricultural sector moves towards the higher productive manufacturing sector. At the same time, simple adoption of foreign technology and facilities and efficient operation based on imported, codified knowledge (e.g. manuals) increase cost competitiveness of the product in the export market. However, as the economy reaches middle income, the above latecomer's advantage disappears and competitors equipped with lower labor cost and up-to-date technology and facilities diminish the rents, which slows growth, and we can observe the country locked in the middle income trap. While the argument explains logically the steps leading to the middle income trap, we cannot determine how to escape.

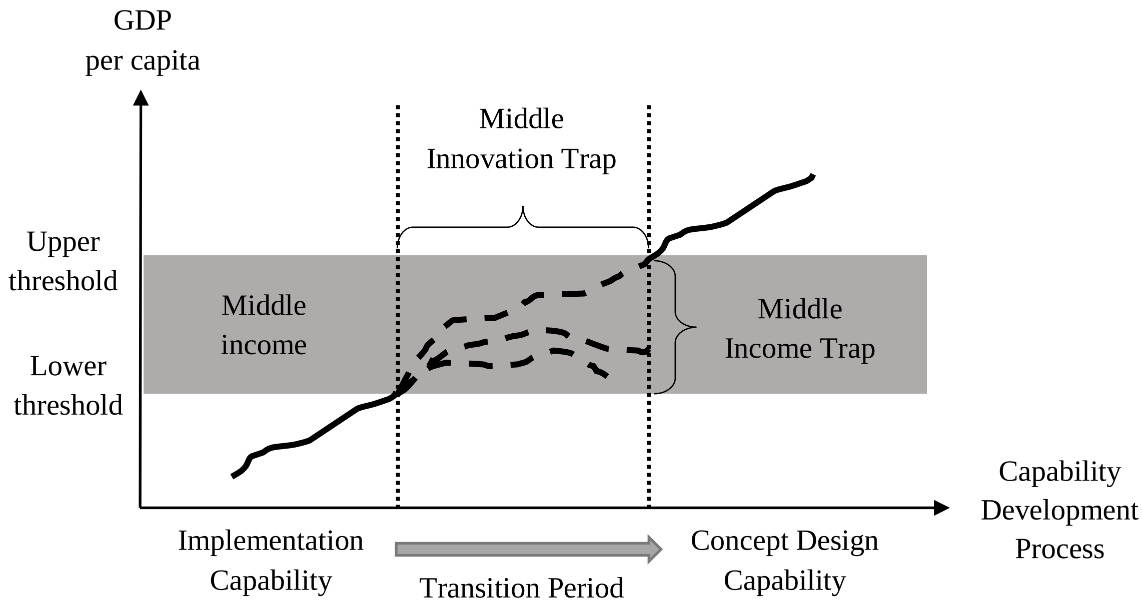
This paper considers the concept of innovation capability to explain the source of middle income trap and the strategies to overcome it. The following section describes the middle income trap as a failure of transformation of core capabilities from implementation-based to that based on concept design. Section 3 discusses the differences between the two innovation capabilities and explains the evolutionary process of accumulating concept design capability. Section 4 compares a coherent innovation system supporting implementation capability and that supporting concept design capability. Section 5 focuses on the reason why it is so difficult to transform the core of innovation capability from implementation to concept design. Section 6 shows three different ways to accumulate experience of creative trial-and-error based on cases: time, space, and strategy for the cases of advanced countries, China, and Korea. Section 7 argues that the concept design capability acquired through trial and error can be worn down for many reasons. Section 8 introduces the concept of four pillars of innovation commons, such as advanced manufacturing base, strong learning capability, cultural framework for trial and error, and consistent innovation policy. The last section summarizes the main arguments of the paper and suggests questions suggesting further research.

2. The source of the middle income trap from the perspective of innovation capability

Any proposal for new product and service requires capabilities to actualize them: (i) Concept design capability to define the specifications and functions of the product or service, and (ii) implementation capability to physically engineer the concept design so that we can touch and enjoy them. Typically, in terms of division of labor, developed countries propose concept designs and developing countries implement them.

The typical process of economic development based on these two innovation capabilities can be described as follows: A developing country starts its economic development with implementation capability to produce products based on the concept designs imported from advanced countries. When the country succeeds in this stage, it is expected to reach the lower boundary of the middle income level. As the country masters higher levels of implementation capability and starts to successfully perform concept design, it will reach the upper threshold of the middle income level. If the country accumulates enough concept design capability, it will become a high-income country. The following Figure 1 depicts the typical stages of economic development according to the development of capabilities.

Figure 1. Stylized development process based on the transition of innovation capabilities



A large number of developing countries reach the lower boundary of middle income level without difficulty, which implies that it is relatively easy to acquire implementation capability. However the observation that most of the developing countries fail to advance to high income level suggests that it is difficult to attain concept design capability. Thus, concept design capability may be considered a sufficient condition to overcome the middle income trap and to become high income country. In this sense the *middle income trap* can be alternatively named as the *middle innovation trap* or *capability transition trap* since failed transformation from implementation based to concept design based capability is the real reason behind the trap.[1]

3. Characteristics of implementation and concept design capabilities

3.1. The difference between implementation capability and concept design capability

If we take the case of constructing a high-rise building as an example, a company with concept design capability will draft architectural designs with new concepts and another company with implementation capability can actualize the given architecture by gathering the necessary resources within a schedule given by the concept design. The concept design and implementation capabilities can be recognized separately in every product and service we utilize ranging from buildings, sneakers, automobiles, microprocessors, and even movie and entertainment programs.

Moreover, we can find similar combinations of concept design and implementation capabilities across all the value chains for all products. In the case of architectural design stage, basic design is made by one architecture company (i.e., concept design) and another engineering company would make a detailed design by interpreting the concept suggested through the basic design (i.e. implementation). A new type of production process, such as the concept design of Just-In-Time (JIT) system, for example, was proposed by Toyota, but implemented by many automobile companies around the world. Likewise so-called global champion companies lay down concept designs and other companies interpret and implement them by combining relevant resources. A country with a large number of companies that can generate the concept designs are by definition a technologically leading country with high income. In terms of 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 time and cost. The following Table 1 summarizes key characteristic features of the two.

Table 1. Key characteristics of implementation and concept design capabilities

Key aspects	Implementation capability	Concept design capability
Mode of expression	Explicit	Tacit
Performance criteria	Efficiency	Differentiation
Strategy to nurture	Learning-by-doing with accumulation of repetitive	Learning-by-building with accumulation of trial and error

	execution	
Time and cost for learning	Low to medium	Medium to high

Implementation capability is expressed mostly in explicit forms such as manuals and, therefore, is easy to transfer. Efficiency in terms of speed and cost is the performance measure to pursue, and repetitive execution reduces time and cost through the learning-by-doing effect. The time and cost to acquire is not that high, so that developing countries can learn implementation capability through 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 upgrade the capability to achieve higher implementation efficiency through its own efforts.

On the other hand, the capability to make a new concept design is often expressed in tacit form such as accumulated experience of professionals and as a form of organizational memory. The criteria for performance is the uniqueness of the products and services. Creative and novel concept design can only be obtained by accumulating the experience of trial and error, that is, through learning-by-building. Due to its tacitness and accumulation effect, it is relatively difficult for developing countries to assimilate this concept design capability from developed countries, which makes the capability a core competitive advantage of high-income countries.

An important point to be reminded throughout this paper is that the transition from implementation capability to concept design capability is not an automatic process. In other words, mastering implementation capability does not necessarily lead to accessing concept design capability.[3] This argument is supported mainly by the observation of the middle income trap that most developing countries fail to reach high-income countries, even with successful acquisition of implementation capability. The theoretical reason for this capability transition failure will be detailed in later sections.

3.2. Evolutionary accumulation process of concept design capability

The concept design capability is critically different from implementation capability, mainly because the former is the outcome of accumulation of creative trial and error. The development process of building up concept design capability shows it clearly. In order to create a novel concept design, first, we need a challenging vision. 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. Third and most important, there should be an accumulation of trial and error by piloting, evaluating, selecting, and recombining of alternative designs. The selection can be made based on internal criteria of the company and/or external criteria of the market and societal and public policy consideration.

These concepts of challenging vision, innovation network, and accumulation of trial and error are highly evolutionary,[4] as much as the process of climbing up to the unknown peak of a mountain: (i) Setting the target, (ii) utilizing local people, establishing infrastructure, and experiencing previous tries, and (iii) climbing up step by step while checking and accumulating the acquired information during the trial and error process and correcting the route. Thus, the process of finding a new concept design is a typical process of exploration full of trial and error (Frenken, 2006).

The three concepts reinforce each other over time to create a positive feedback loop. When a new concept design (D1) is made, we can accumulate all the trial and error (T1) behind the resulting concept design (D1) with outside information through networking (N1). This accumulated trial and error will constitute the key resources to reach the next stage of concept design (D2=D1+T1+N2) with information added through networking (N2). The accumulated experience (T1) would also spillover to other actors in the country to make their own concept design. Thus, a company with experience of successful concept design and trial and error can set a more challenging vision, can form a wider network with higher capabilities, and most importantly, can tolerate longer period of accumulation of trial and error, which makes the company build up higher level of concept design capability. This typical evolutionary process with positive feedback relationship among components renders a larger gap between developed and developing countries over time, and we observe the middle income trap.

4. Characteristics of innovation systems based on implementation and concept design capabilities

4.1. Set 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 the paper is that the sets of routines are different according to the core capabilities based on implementation or concept design. It can also be a reflection of innovation system at the company level, which implies that an innovation system based on implementation capability would be different from that based on the concept design capability. In order to check the difference of company routines, the following four aspects should be checked: (1) objective of production/innovation, (2) performance evaluation and compensation system, (3) organizational structure and communication style, and (4) perspective on the trial and error.

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

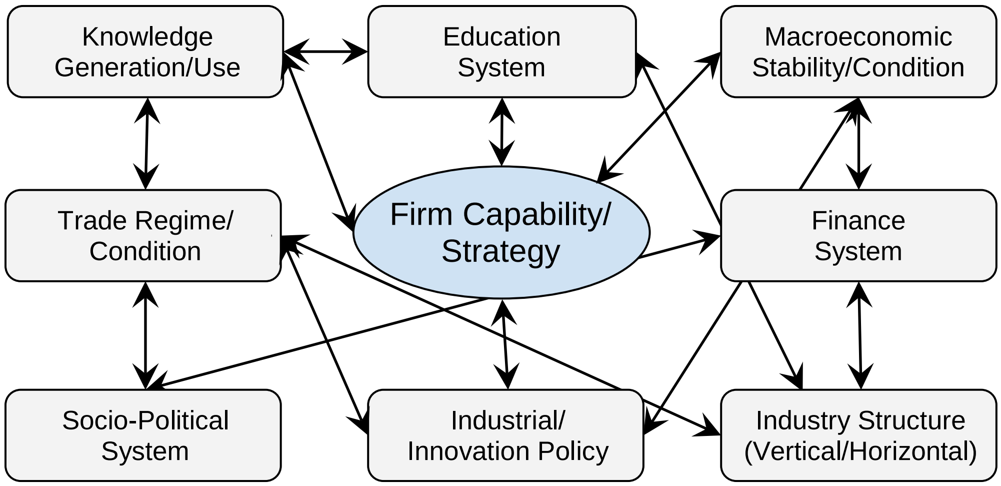
On the other hand, when a company bases its core capability on proposing new concept design, differentiation is the objective of production/innovation. Performance evaluation and compensation criteria are based on longer term and intangible outcomes, and autonomy and recognition among peer professionals are considered more important incentives than monetary reward. Horizontal communication structure and network style organizational structure are preferred in order to increase the probability of unexpected combination and serendipitous discovery. Trial and error are encouraged and routines emerge to systematically retain organizational experiences.

Following up the discussion on the different characteristic features of the two capabilities, the above arguments imply that the set of routines of a company creates a coherent innovation system that lets certain types activities prevail. Companies in developing countries generally has a set of routines surrounding implementation capability, and it becomes more difficult to transform into a set of routines based on concept design capability, as they achieve greater successes based on the former capability. This constitutes a typical example of lock-in and path dependency in the innovation system (Dosi and Nelson, 2010). In other words, in a successful developing country, a young entrant, not locked-in implementation capability routines, is more promising to acquire the concept design capability, than successful incumbents based implementation capabilities.

4.2. Characteristics of national innovation system according to different core capabilities

A national innovation system is a collection of institutions that regulate the generation, diffusion, and utilization of knowledge. As Amable (2000) presented, it is described as a coherent system that consists of systems in finance, education, knowledge, trade, socio-political, industry structure (vertical/horizontal), macroeconomic condition, and innovation policy with firm capability and strategy as its core. The following Figure 2 depicts the schematic relationship among sub constituent systems.

Figure 2. National production/innovation system as a coherent institutional arrangement



For the case of a developed country, the characteristic features of a national innovation are harmonized and reinforce concept design capability, such as an education system focusing on creativity and hands-on experience, a well-developed venture capital system to support 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 on the historical, geographical, and cultural specificities, all share commonality that support challenging vision, innovation network, and accumulation of trial and error to nurture concept design capability further.

4.3. The case of Korea as an implementation capability based innovation system

The history of the Korean economic development illustrates that the characteristics features of the national innovation system are closely interlinked to make a coherent system. When the Korean economy reached the middle income level, it was characterized by its efficient implementation capability, and some of the key features support that capability can be summarized in the following Figure 3.

Each feature of the innovation system is closely interlinked to reinforce each other.[5] For example, in order to secure enough number of workers for the industrial development in a relatively short period, the government invested heavily in education infrastructure focusing on elementary and secondary level together with a strong emphasis on vocational education. The main educational goals also focused on the basic literacy skills, math, and ethics for industrial society (*education system to support industrial activities*). The six heavy and chemical industries of steel, petro-chemical, automobile, electronics, shipbuilding, and machinery industries, which were all capital intensive and technologically mature, were selected in order to minimize trial and error but to maximize the learning-by-doing effect focusing on efficient execution and operation (*concentration on capital intensive and mature industries*). Large business conglomerates (so called, *Chaebols*) were promoted to maximize the effect based on the economies of scale and scope (*large enterprise dominating industry structure*), and bank-backed financial system supported their big 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 the planning and monitoring stage *(public-private partnership in all policy domains*). Export-orientation was the most important performance criteria in all the national level decision making for industrial development (*Export-orientation*). The knowledge sector of public research institutes and universities focuses not on creating an inventive technology new to the world, but on interpreting and disseminating the foreign technology into local enterprises with negligible absorption capacity (*assimilation and diffusion based technology strategy*).

All the above characteristic features, ranging from education, finance, trade regime to industrial policy, collectively reinforce the implementation capability up to 2000. As Nelson (1993) showed, a large number of countries in the middle income status share similar coherent system for implementation capability, even though the portfolio of components in the system may be different across countries depending on the historical and cultural backgrounds each country had.

4.4. Lock-in effect and the difficulty to transform from an implementation based into concept design based innovation system

Once the institutional arrangement is set based on implementation capability, the incentive system works to favor activities to reinforce implementation capability. 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 the trap where human resources are unavailable, concept design capability erodes, uncompetitive companies focus on concept design, negatively affects firms' abilities to attract capable human resources, and more strongly locks-in implementation capability routines.[6] This is the reason why we can observe most of the middle income countries fail to move up the ladder.

The history of the automobile industry in Thailand is a good example of a coherent system focusing on implementation capability with specific set of industry performances.[7] Thailand pursued a CKD (Complete Knock-Down) style OEM (Original Equipment Manufacturing) strategy from the outset of the automobile industry from the early 1960s, which focused on the assembly of imported part and components. This strategy minimizes trial and error and establishes an industrial base in a short period of time based on imported facilities and manuals focusing on efficient operation. In order to help the execution of implementation strategy, the Thai government established an automobile cluster and provide fiscal and institutional incentives to attract MNCs (multi-national companies). The government also supported the provision of labor with basic skills for the assembly line and provided incentives for export activities. As a result, Thailand emerged rapidly as an Asian automobile production and export hub for major MNCs with minimal error, and automobile sector took a major share in terms of GDP and employment, which may be considered the main benefit of the fast implementation strategy.

Unfortunately, the coherent system locked-in implementation capability that hinders innovation activity with trial and error, which is expected to provide domestically-generated concept designs in every segment of the industry ranging from design, production, parts and components, and marketing. Now almost all the major automobile producers in Thailand economy are MNCs which also enjoy most of the rents. Meanwhile, local manufacturing companies in the parts and components sector are left with the small remaining share, leading to low value added and profitability. Worse than that, important variables, such as production volume, product portfolio, and export market strategy, even the number of employment, and so forth, depend critically on the managerial decision of MNCs headquarters outside Thailand. From time to time, the Thai government has set the policy initiative to upgrade the capabilities of the automobile industry, without noticeable effects.

It is not an easy task to transform the core capability from implementation based to concept design based, mainly because all the components in the coherent innovation system surrounding implementation capability should change simultaneously. Moreover, the components of innovation should change according to the development stages and changes in external business environments. In short, coevolution of coherent system is required for the transformation of innovation system. However once a specific type of coherent innovation system is organized, vested interests emerge that block changes. Thus, we observe a large number of countries that have succeeded in obtaining implementation capability trapped in the middle income trap, because most of them fail to coevolve of all the components locked in the implementation capability. This is the real source of middle income trap from the perspective of innovation capability.

5. Three strategic tools to accumulate trial and error experience: Time, space and policy

Accumulation of trial and error is the critical prerequisite for creative concept design, since a new concept design is by definition an unknown artifact, which can be made or found only through exploration. If we take the new generation of microprocessor chip as an example, there must be numerous tries, evaluation, selection, and retest different combinations of new materials, new architectural structure, new programming logics, and new assembly equipment, to name a few.

Advanced countries, which enjoy high income levels and lead industrial development with their own concept designs, have accumulated trial and error of private entrepreneurs, researchers, and organizations to make new concepts at least since the Industrial Revolution in 18th century. They accumulated the experiences not only inside corporations but also in society in general. As the trial and error experience accumulates, more challenging target setting has been allowed and the depth and breadth of innovation network evolved further, which renders a higher rate of accumulation of trial and error over time. Therefore, *time* is the main strategic keyword of advanced countries to accumulate trial and error.

There is a limited number of developing countries that escaped the middle income trap by building 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 colonial period (1910-1945) and the Korean War (1950-1953). Within five decades, Korea managed to overcome the middle income trap based on key concept designs in targeted high tech sectors.

Korea started its economic development during the mid-1960s with a GDP per capita level of less than USD 1,000 and reached its middle income status in the mid-1980s. Implementation capability advanced during the 1960s through the 1980s contributed to cost competitiveness in the international export market, and coherent policy framework supported efficiency based implementation capability of private sector. From the mid-1980s, Korea started to run the virtuous cycle to obtain concept design capabilities in key sectors. The efforts finally paid off as world class concept designs were developed in targeted high tech sectors from the early 1990s, such as next generation DRAM chips, display technologies, new automobile engines, LNG (liquefied natural gas) carrier ships, to name a few. With the advent of domestically-generated concept designs, the export product portfolio changed dramatically in a short period of time.[8] We can find some common factors behind the buildup process of concept design capability (Kim, 1997; Lee and Baek, 2011). First, visionary target setting was made based on the public-private partnership. Second, global networking was pursued aggressively with experienced knowledge hub through various activities such as licensing, recruiting, and co-development. Third, trial and error experience accumulated based on wide and diverse 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 mobile communication 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 previous 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 7 years of trial and error to finally arrive at concept design (accumulation of trial and error). It provided the technology platform for 27 billion USD worth of mobile phone export in 2015 according to the trade statistics.

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

China, on the other hand, provides an alternative model, since recently it has started to generate its own concept designs in the field of complex system sectors, such as high-speed trains;

electricity generation and transmission technologies; consumer electronic products, such as mobile phones; and new business models, such as e-payment system. Like Korea, China lacked absolute time to accumulate trial and error, but it accelerated the accumulation process with 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 is larger than those of any other country including advanced countries. 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 upgrade the innovation network.[9] Moreover, the export market dominated by Chinese products played a role of platform to accumulate trial and error by exposing domestic entrepreneurs to diverse market needs. Exports provide an opportunity to accumulate trial and error when creating new product demand to the world market. With all these observations in mind, we know that *space*, which is the size of the market for the case China, is another strategic way to accumulate trial and error for nurturing concept design capability.

The case of Korea developing concept 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 cannot be transferred. A strategy that uses a policy platform focusing on components of an evolutionary process for concept design—a challenging vision, innovation network and accumulation of trial and error—provides a means to compress time and space.

6. Erosion of concept design capability

6.1. Current challenges of the Korean industry

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

Korea is known as one of the benchmark cases in that it overcame the middle income trap based on own concept design capabilities in some high tech sectors. Evidence that supports the above argument is the new products in mobile, automobile, display, and shipbuilding industries, and 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 new major entrants and the top export items have not changed, which signifies the slower speed of industry dynamics.[10] For the last decade at least, the profitability rate of the manufacturing sector and overall investment rate have steadily declined, and accordingly, we are observing a gradually decreasing GDP growth rate.

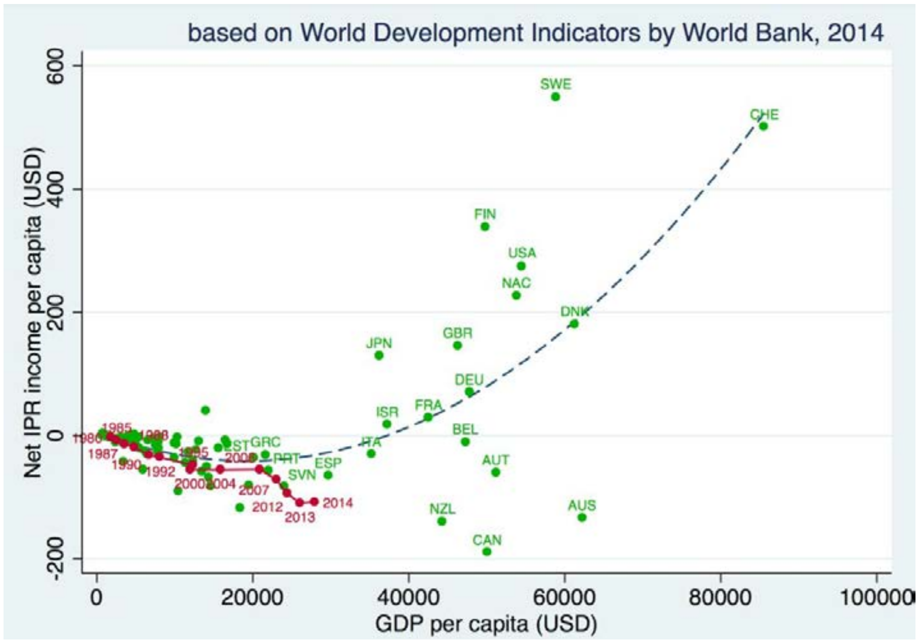
Some analysts are concerned about the possibility of Korea entering a prolonged and structural depression similar to what Japan endured for the last two decades.

In the current Korean industry 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 large number of companies that are still locked in implementation capability. 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, for example. Moreover they may relocate the 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 these global companies and local actors have weakened over time. Thus, the linkages between exports and the local economy and between GDP growth and local employment are lost.

The gap between global companies and local actors in terms of innovation capability is the shadow of successful industrial policy up to the 90s. 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 the resources with institutional support. Most of the other companies were left with limited resources to accumulate trial and error and, as a result, remained with implementation capability. On average, many aspects of the national level institutional framework still hinges 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 aspects 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, and vertical industry relationships leave room for improvement in terms of a 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 be still in the middle innovation trap at the national level.

The following figure shows the relationship between GDP per capita and IPR (intellectual property right) net export per capita across 88 countries with available data in the World Development Indicators by World Bank published in 2014. The sample excludes countries with less than 1 million population, small land size, 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 in the red line) seems to deviate from the stylized pattern of 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.

Figure 3. Relationship between economic performance and net IPR income by country, 2014



All these characteristics still focusing on implementation capability will eventually have detrimental effect on the concept design capability that has been obtained by a few global companies, since they are also part of the innovation system. Therefore, it is highly needed to narrow the gap in terms of innovation capabilities among companies, and to set national level policy framework to nurture concept design capability.

6.2. 'Combination Trap' of China and 'Service Trap' of European Countries

China and some European countries may find themselves in some form of economic development trap. While China may find itself in a 'combination trap,' European countries may be in a 'service trap.' China has started to provide its own concept design in some areas based on its large domestic market that serves as a platform to support trial and error. The Chinese market is huge, but at the same time quite heterogeneous in terms of income, preference, and geography, to name a few aspects, which makes the China look like a collection of numerous niche markets. Moreover, the portfolio of niche changes dynamically as the economy grows. Thus, companies try to compete to dominate in each niche market and in doing so, the society accumulates collectively the experience of trial and error for new concept design. This generates a high speed of new combination to increase the probability of a novel concept.

However, there may be too much attention given to the speed of combination due to fierce competition. The parts and components sectors, which requires a relatively longer time perspective to accumulate experience, may be neglected. This may explain why new products announced by high tech Chinese companies depends critically on the key parts and components from foreign companies with concept design capabilities in these areas. This argument implies a paradox that China is facing; the size of its domestic market may be double-edged sword. On the one hand, it plays a role to encourage trial and error, but on the other hand, it may leave the parts and components sectors neglected, which may be described as a *combination trap*.

On the other side of the globe, we have Portugal, Island, Greece, and Spain facing a competitiveness problem in the European context, which were recognized by World Bank (2012) to successfully overcome the middle income trap. Even though they are now categorized as high-income countries, their industrial competitiveness is quite fragile. Some of the commonalities among them are as follows: First, the manufacturing base is very weak, so that it is highly difficult to pilot any ideas on new concept design. Second, they all have high levels of government debt, which hinders active public investment to nudge challenging tries and to share the accompanying risks. With these characteristics, we expect the concept design capability of these countries, if any, to erode. Thus, we know that the above European countries are in the middle of innovation trap anew or again, which may be called a *service trap*.

The above discussion implies that the concept design capability may wear down, if the virtuous cycle for creating concept design no longer works or the speed of the feedback loop slows. Growth slowdown is only the external representation of internal problem: the erosion of concept design capability.

7. Innovation Commons as a platform for concept design capability

Securing concept design capability needs simultaneous changes of all institutional arrangements of the national innovation system ranging from education, finance, industry structure, trade regime to industry/innovation policy, that is, the coevolution of a coherent system. This also demands concerted changes of all actors, which is difficult since the incentive schemes do not match dynamically. In order to facilitate concomitant actions of individual actors, we need the concept of an *innovation commons* as a platform with tangible and intangible parts to mobilize the actions. Specifically we have to define an innovation commons for concept design capability, which contributes to nurturing the key components of evolutionary process of concept design: challenging vision setting, networking, and accumulating trial and error.[11] Based on the innovation system theory and stylized evolutionary process of innovation, the following four factors should be included: (1) A strong advanced manufacturing base, (2) learning capability to nurture professionalism, (3) socio-cultural institutions to favor the accumulation of trial and error, and (4) consistent innovation policy to lead change.

Innovation commons 1: A strong advanced manufacturing capability as a platform for trial and error

An advanced manufacturing plant is a good job creator, but more importantly it provides the physical platform to test prototype concept designs. Japan is well known for its strong manufacturing capability, which allows the economy to maintain competitiveness even during a prolonged depression.[12] It is a proven stylized fact that the speed and quality of building a new concept design improve greatly when innovation and production sites are located nearby (Nahm and Steinfeld, 2014).

Innovation commons 2: Learning capability to nurture professionals

Concept design capability ultimately resides in the memory of professionals and as an organizational routine. Professionals with learning capability welcome new ideas and feel comfortable entering new fields. Therefore learning capability should be one of the most important commons from which every actor can benefit.[13] However individual companies may not be able to appropriate all the returns out of an investment to nurture professionals due to job turnover, for example, and thus, it requires public intervention. In order to promote learning capability, we need first to establish career development paths for professionals with accumulated trial and error for a long time. Second, the absolute amount and relative share of labor compensation should be increased, which, in turn, would increase the investment to voluntarily accumulate trial and error.

Innovation commons 3: Socio-cultural institutions to favor the accumulation of trial and error

A society should have a socio-cultural environment to tolerate trial and error, mainly because new concept designs are the only outcome of accumulated trial and error. In contrast, when a country is based on implementation capability, trial-and-errors are factors to minimize, and socio-cultural institutions are set to avoid error as much as possible. In order to actualize this socio-cultural commons, first, we need to make a rational society open to every critical but constructive debate, because trial and error can only happen with active debate, not through strict hierarchy. Second, trust is the intangible basis for trial and error. Without trust, short-term based tangible output measures would be used for performance criteria, and as a result, a challenging mission to target novel concept design would not survive, because they are highly associated with long term results and with high probability of failure.[14]

Innovation commons 4: Consistent and coherent innovation policy to lead change

An innovation commons requires active policy intervention, mainly because, as we conjecture 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 considering the key components of evolutionary process for concept design.[15] First, the role of 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. Thus, there must be policy consensus on the appropriate role and responsibility of finance sector to support trial and error. Second, public procurement can play an important role of test bed for innovative concept designs. If it appeals to the public interest, we have a good rationale to spend taxpayer money even on expensive but innovative products. Third, research organizations including universities and public research institute should be heavily supported for long term and risky projects. These are all policy tools to spread and share the risk associated with concept design process.[16]

8. Summary with questions requesting further researches

8.1. Summary of the main arguments

To make a new product or service, we need concept design capability to set the definition and an implementation capability to actualize 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 capability to reach the middle income level with relative ease. However, most countries fail to get out of middle income level, mainly because they cannot obtain concept design capability as a pre-requisite to become high income countries.

The capabilities based on implementation and concept design entail different sets of routines, which implies a different collection of characteristics features of the innovation system. Implementation capability sets the target on higher efficiency based on learning-by-doing and aims at minimizing trial and error. On the contrary, concept design capability targets differentiation based on learning-by-building and accumulates experience of trial and error. Once an innovation system of a developing country is locked in on implementation capability, then it becomes more difficult to transform itself into concept 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 to cross the chasm between the two innovation capabilities.

Accumulation of creative trial and error is the most important component to develop concept design capability. Advanced countries accumulated them since the Industrial Revolution in the 18th century, which means they accumulated trial and error through *time*. China, as an emerging industrial hub, is accumulating trial and error 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 the time and space required for accumulation of trial and error through coherent *strategy*, which provides interesting lessons for most developing countries in the middle income trap and without enough time and space.

An innovation system based on implementation capability is different from that based on concept design capability, which implies that the transition requires the concerted actions 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 framework change, specifically to promote creative trial and error. Innovation commons consist of four factors: a strong advanced manufacturing base, learning capability to nurture professionalism, socio-cultural institutions to favor the accumulation of trial and error, and consistent innovation policy to lead change. All are directed to reinforce the evolutionary process of concept design development.

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

8.2 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 the questions that await further research efforts:

- What would be the appropriate measure of implementation and concept design capabilities at the company and national level?
- What are the critical factors to affect the speed of accumulation of creative trial and error for new concept design?
- What is the taxonomy of industrial/innovation policy to help private companies build up concept design capability, and the rationale for policy intervention?
- What is the relationship between production and innovation from the perspective of accumulation of creative trial and error?
- What are the categories countries in terms of innovation capabilities?
- Is there sectoral difference in terms of strategy to obtain concept design capabilities?
- Can we interpret the stagnating growth performance of South American countries, East European countries, resource abundant countries, and transition countries based on the innovation capability concept?

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[1] Recently, Vivarelli (2014), Kang et al. (2015), and Lee (2015), among others, try to use the concept of technological capabilities when they discuss middle income trap.

[2] Kim (1997) highlighted the difference between imitation and innovation in terms of capabilities, and showed persuasively that developing countries in general start their economic development by imitating the technology and product from advanced countries and move to the innovation stage with the case studies of the Korean companies in the development stages. While imitation, in Kim (1997)'s discussion, refers to the copy of products produced in the advanced countries, implementation in this paper indicates the actualization of concept suggested by the companies in advanced countries. The OEM (Original Equipment Manufacturing) model based on the design concept of advanced countries, which has been quite the prevalent mode of production in developing countries, signifies the importance of implementation capability, not imitation capability, as important base capability of companies in developing countries.

[3] Lall (2000) emphasized the difference between the concepts of 'know-how' and 'know-why', which may correspond to the implementation and concept design capabilities in this paper. His main argument is that even though know-how can be obtained through learning in areas of process engineering, quality control, maintenance routine, we cannot get know-why of the system, because it commands a totally different knowledge dimension.

[4] The three components correspond collectively to the traditional components of evolutionary process: variation (V), selection (S), and retention (R) (Dosi and Nelson, 2010). For the first component, we understand that with a more challenging vision, we become more aggressive to 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 over longer periods affects the quality and quantity of retention (R), but at the same time, has a positive effect on variation (V) and selection (S) indirectly. The above discussion implies that the suggested evolutionary components of concept design development accommodate theoretical rationales of evolutionary economics. Moreover they reflect micro routines of concept design capability we can observe on a daily basis at the company level, and they are more intuitive.

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

[6] Agenor and Canuto (2012) provides a neoclassical growth model accommodating the concept of design sector and the incentive effect. The argument of the vicious cycle focusing on implementation capability in this section is based on Agenor and Canuto (2012)'s analysis on the low equilibrium state.

[7] The general development history of Thailand automobile industry can be found in Natsuda and Thoburn (2011). Felipe and Rhee (2015) also explains the case of Malaysian automobile industry, which has developed based on FDI and fails to upgrade its indigenous production/innovation capabilities, as same as the case of Thailand presented in this section.

[8] The main export items in the early 1970s was 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.

[9] China has maintained a 50:50 ownership structure for FDI companies, which contributed much to the spillover effect from foreign to domestic companies (Felipe and Rhee, 2015).

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

[11] Pisano and Shih (2012) suggest the concept of an industrial commons to support production/innovation activities for rebound of the US economy. They specified advanced manufacturing base as the single most important industrial commons. Here innovation commons as an extended concept from industrial commons are suggested to covers tangible and intangible factors, such as culture to tolerate trial and error, for example.

[12] The sources of Japanese manufacturing capabilities can be found in Fujimoto (1999).

[13] Stiglitz and Greenwald (2014) emphasized the important relationship between education and economic development. Mehta and Felipe (2014) found the positive relationship between education and economic diversity.

[14] The relationship between trust and innovation was discussed in Dirks and Ferrin (2001). Harrison and Hunttington (2000) and Rodrik et al. (2002) argue that institutional quality including level of trust positively affect economic growth.

[15] Among others, we can find recent arguments for active role of industrial and innovation policy in Mazzucato (2011) and Stiglitz et al. (2013).

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