Neighbours with different innovation patterns: the implications of industrial and FDI policy for the openness of local knowledge production

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This article shows evidence that FDI policies during the catch-up process may leave a trace in the openness of innovation activities in latecomer economies, based on a comparative analysis between the Republic of Korea and China. The past industrial policies of the Republic of Korea favoured creating local technological competence based on the transfer of foreign knowledge in codified form, leading to a low level of global connection in local knowledge creation. By contrast, Chinese policies encouraged the entrance of foreign firms in the Chinese market, leading to a higher level of global interaction in innovation activities. Based on the findings, the article presents policy recommendations and suggests avenues for future research.

Keywords: China, FDI policy, innovation, openness, the Republic of Korea, South Korea, technological catch-up

1. Introduction

The role of the state in the catch-up of latecomer economics has been well documented (Öniș 1991; Amsden 1992). Especially in the case of East Asian countries such as the Republic of Korea (henceforth South Korea), Taiwan, Province of China (henceforth Taiwan), Hong Kong (China) (henceforth Hong Kong), Singapore, and more recently, China, government intervention with strategic industrial policy proved effective in achieving rapid economic growth (Chowdhury and Islam 1993). While there are studies looking into the impact of industrial policies on the capability building and economic growth of the latecomer economies (e.g. Kim 1999; Mah 2007; Chu 2011), scant attention is paid to the implication of industrial policies for *how* latecomers innovate. In this study, we draw attention to how industrial policies during catch-up periods may influence the innovation pattern of these economies during and after the catch-up periods.

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We observe an interesting pattern in the patenting activities of China and South Korea, which could partly be attributed to the different industrial policies of the two countries. Based on a comprehensive review of industrial policies and analyses of the patenting activities of the two countries, we postulate that the difference in FDI policies, in particular, may have led to different levels of global connectivity to innovation activities.

Studying innovation patterns of latecomer economies is invaluable since innovation capability constitutes a driving force for continuous economic growth once latecomer economies "catch up" with advanced economies based on imitation (Awate, Larsen and Mudambi 2012). While there are many studies on learning and capability building of latecomers in the imitation process, the consequent innovation activities of latecomers during and after the catch-up period deserve more attention (Lee and Yoon 2010). Besides, the factors affecting the innovation patterns of latecomer economies should be studied from diverse angles, and we intend to do so by reflecting on the industrial policy implications for local knowledge creation.

Within the innovation literature, economic catch-up of latecomer economies is explained mainly by the processes of technology transfer and local technology capability building (Fu, Pietrobelli and Soete 2011). As latecomers lack indigenous knowledge in the early process of catch-up, creating global connections to get access to advanced knowledge abroad is critical for technological capability building. However, being exposed to foreign technology is not sufficient for catch-up and should be accompanied by local innovation capability building for sustained economic development (Lee, Szapiro and Mao 2018). Building knowledge infrastructure and the human resource base are fundamental for enhancing absorptive capacity when it comes to utilising and developing advanced technology from abroad. All in all, the interaction between global technology transfer and local capability building sets out the prospect for the success of technological catch-up, and the industrial policies of latecomer economies tend to focus on facilitating these mechanisms of catch-up.

What is often overlooked in this context is that different technology transfer mechanisms can contribute to shaping diverse patterns of local knowledge creation. Global interaction facilitated through industrial policies will influence the possibility of utilising foreign sources of knowledge in innovation. While China and South Korea had similar sets of policy instruments to facilitate technology transfer and local capability building, one policy area in which these countries diverged markedly was FDI-related policy. As FDI policies directly influence the level of interaction between local and foreign firms in the host and home economy, active FDI policies can create opportunities for cross-border collaboration in innovation. The potential link between FDI policies and the openness to innovation activities provides insight about the long-lasting impact of FDI on host economies, which has not been discussed extensively in the literature before. This additional insight is relevant for further developing UNCTAD's investment policy framework for sustainable development (UNCTAD 2015).

Our main contribution, therefore, is to show initial evidence that acknowleges the neglected link between trade-related industrial policy and the openness of innovation efforts of latecomer economies. Furthermore, we expand the current discussion about innovation policy in developing economies by raising awareness that trade-related industrial policy during the catch-up process, and not only science and technology-related policy, can also influence the innovation pattern in latecomer economies. As the conditions of catching-up economies for enhancing innovation capacity are dissimilar to advanced economies conditions, more studies on government policy relevant for latecomer economies' innovation capability building are needed.

The paper is structured as follows. We present the theoretical background of the technological capability building of latecomer economies and the government policy for catching up. Building on this understanding, we discuss the role of industrial policies in shaping innovation activities in latecomer economies. Then, we move on to present how various industrial policies, including FDI policy, unfolded in South Korea and China and show the divergent development of the knowledge creation pattern over time in the two countries. We discuss the implications of our findings and conclude with policy recommendations and suggestions for future research.

2. Government policies in support of mechanisms for technological capability building during the catch-up process

For latecomers that aim to catch up economically with advanced economies, narrowing the technological gap that exists between them and developed economies is of utmost importance (Abramovitz 1986). As the initial technological knowledge base is limited in these economies, technological assimilation starts with learning from advanced economies (Nelson 2008). Before entering the innovation phase, during which new knowledge creation takes place, the latecomers will have to imitate technologies developed by forerunners and accumulate technological capabilities (Lee, Jee and Eun 2011). To be able to learn from the advanced economies, getting access to foreign knowledge and local capability building becomes crucial for catching-up economies.

First, latecomers need to utilise various channels for technology transfer from abroad in the process of learning and capability building. Fu, Woo and Hou (2016) specify the channels for technology transfer as i) licensing, ii) movements of goods through international trade, iii) inward and outward foreign direct investments (FDI), iv) movement of people, v) international research collaboration, vi) diffusion of disembodied knowledge through media and internet, and vii) integration into global value chains (GVCs).

By purchasing foreign capital goods or licensing, firms in the latecomer economies can directly get access to foreign technologies and develop technological competences through reverse engineering or utilising the capital goods in the production processes (Lee and Lim 2001). While this form of technology transfer relies more on learning from codified knowledge than tacit knowledge, other channels provide opportunities to transfer tacit knowledge. Inward FDI may facilitate local firms' interaction with foreign firms in geographical proximity (Luo and Tung 2007). Firms can get technology transferred and enhance their capabilities through the establishment of international joint ventures with foreign firms, as in the case of the Chinese automotive sector (Chu 2011). Besides getting involved in a direct transaction with foreign firms, local firms can also benefit from knowledge spillover from foreign firms (Branstetter 2006).

Similarly, outward FDI by firms from emerging economies allows firms to get access to advanced knowledge abroad (Deng 2007; Paul and Benito 2018). Emerging economy firms can establish research and development (R&D) centres in technology hotspots in advanced economies through greenfield investment and tap into new knowledge by hiring highly-skilled local employees or through collaboration with local universities. When latecomer firms acquire firms abroad, the former do not only get access to codified forms of knowledge such as machinery, plants and patents, but they can also take over employees from the acquired firms which then induces transfer of tacit knowledge. Another way to get access to foreign knowledge in the interactive setting is to be a part of a GVC by supplying to foreign buyers. Upgrading in the GVC suggests that latecomer firms can learn and enhance their technological competences through interaction with foreign buyers (Gereffi 1999). The learning opportunities arise when the latecomer firms are exposed to the advanced practices and processes of buyers and when buyers set specific technological requirements for the products or services.

Industrial policies that open up the economy and support local firms to participate in global markets through the mechanisms mentioned above can, therefore, constitute an essential part of "innovation policy" for latecomers. For example, active FDI policy inducing the entry of foreign multinationals in the domestic market and thereby creating interaction between local and foreign firms has been witnessed in many Asian countries such as Hong Kong, Singapore and China. Local content and import substitution policies that require firms to replace imported components with locally-produced ones have increased local firms' participation in global value chains in many developing economies including South Korea, China, Pakistan, and South Africa (Amsden 1992; Barnes and Morris 2008; Khan, Lew and Akhtar 2016). The requirement for foreign firms to establish joint ventures with local firms allows latecomer firms to get direct access to critical technological knowledge and induces the effective utilisation and further development of the technologies (Mu and Lee 2005).

While getting access to advanced foreign knowledge is a fundamental pillar in the catch-up process, developing local technological capability in using and developing the knowledge further is found to be another crucial pillar (Abramovitz 1986; Bell and Pavitt 1992). As it was initially suggested by Kim (1980, 1999), the term "technological capability" represents the ability to make effective use of existing technological knowledge and develop new knowledge. For catching-up economies in the early stage of economic development, mastering effective utilisation of existing knowledge is likely to precede the generation of new local knowledge. The active usage of existing knowledge may induce a learning effect and provide the foundation for the development of new knowledge. Similarly, Abramovitz (1986) asserted that "social capability", which represents the capability to exploit technological opportunities, is vital for catching-up. This capability stretches beyond the mere accumulation of the technological knowledge stock. It is associated with general technical competence (education) level, mobilisation of capital, the organisation of firms, and other social and political institutions.

The government intervention can be geared to enhance the technological infrastructure, including the education system and other formal and informal institutions related to local competence building. Establishing and reforming ministries, research institutes and the education system, in particular, are fundamental for building up local technology competence (Lee, Jee and Eun 2011). With regards to local human resource development, governments can provide scholarships for studying abroad and design effective incentives for the diaspora to return to the home country with new knowledge obtained from abroad. Government-funded R&D projects and public-private research consortia have also been found to be effective for building local technological competences and encouraging university-firm collaboration in creating new indigenous knowledge (Lee 2005). Vertical industrial policies picking and supporting a few "winners" within specific industries also help to enhance the technological capability of the chosen firms by providing subsidies and funds for research and development activities.

3. Industrial policy as innovation policy and its implication for the openness of the economy towards foreign sources of knowledge

As discussed above, having an open innovation system towards foreign sources of knowledge and enhancing local technological capability is critical for latecomer economies (Fu, Woo and Hou 2016). Depending on specific policy instruments used in the catch-up process, latecomers will go through different learning processes utilising different channels and mechanisms of knowledge transfer within and across the national economy boundary. The cumulative process of technology-capability building will lead to the development of national innovation systems with diverse patterns of knowledge transfer, creation and diffusion over time (Lundvall 1998). This suggests that the collective sets of industrial policies that shape the industrial structure and the general business environment in the development phase of a developing economy will leave imprints on the way that knowledge is created, shared and utilised in the economy.

Following this line of argument, we can assume that industrial policies do not only induce learning opportunities for latecomer firms in the catch-up process, but they may also leave a lasting effect on *how* local firms innovate in terms of their utilisation of foreign knowledge. In general, industrial policies that are more open towards the global economy will facilitate the opportunities for local firms to innovate in collaboration with global actors. For example, active FDI-related policies increase the presence of foreign firms and their integration into the local business environment. While engaging in business relations with foreign firms, local firms get opportunities to develop new products and/or services and processes in collaboration with foreign firms. Furthermore, local subsidiaries of foreign multinational firms can get into joint development projects with other subsidiaries of the firm (Berry 2014). The possibility for local firms to be integrated in the global innovation system will therefore be higher compared to the chances of firms in more closed economies. Similarly, outward FDI from latecomer economies will also enhance the possibility of local firms to connect to the global innovation system. Foreign subsidiaries of latecomer economy firms can transfer foreign knowledge to headquarters through organisational pipelines.

Studying the implications of industrial policies for the openness of innovation systems expands the current understanding of the impact of the policies on developing economies beyond the domain of catch-up and upgrading. For example, if we take the implications of FDI policies for economic development, most of the studies focus on spillover effects on the performance of local firms in terms of profitability and productivity (Rutkowski 2006; Wei and Liu 2006; Konara and Wei 2017). Similarly, the recent discussion about FDI-induced development and upgrading through “new” industrial policy focuses primarily on the potential of local firms to enhance their capabilities by moving into higher value-added activities and the associated spillover effect on the local economy (Buzdugan and Tüselmann 2018).

However, some latecomer economies (e.g. Japan, South Korea, and possibly China) managed to make the transition from being imitator to innovator once they had accumulated technological capabilities. It is also observed that the pattern of technology transfer from abroad and the utilisation of foreign sources of knowledge change throughout this development (Lall, Cantwell and Zhang 2009). Following this transition and studying the impact of FDI policy on various aspects of the innovation pattern with a long-term perspective will be of critical value to other developing economies that aim to achieve innovator status. The openness of innovation systems towards foreign sources of knowledge and how economies utilise local and foreign sources of knowledge are critical for the sustainable development of economies, regardless of their development status. While too much dependency towards foreign knowledge sources may interfere with the development of local indigenous knowledge, too little connection to foreign knowledge sources can lead to lock-in because it limits the possibility of diversifying knowledge bases at home. Since managing local and foreign sources of knowledge has critical implications on the development of innovation systems, it is necessary to acknowledge that the formulation of industrial policies may influence the openness of innovation system in the trajectory of technological capability building.

4. Government policies supporting technological capability building in South Korea and China

The analysis of the economic development of East Asian countries has often highlighted the similarities of the development pattern in these countries as shown in the “flying geese model” and the notion of the “developmental state: and “East Asian tigers” (Öniș 1991; Kojima 2000; Mathews and Cho 2000). Except for Japan, whose growth preceded the rest of the countries, the East Asian countries (South Korea, Taiwan, Singapore, and Hong Kong) have gone through rapid economic growth throughout the 1980s and 1990s, based on the opportunities arising from the electronics and information and communication technology (ICT) sectors. As a follower in the region whose development took off around two decades later, China shows a distinctive development path compared to the “East Asian tigers”. Lee, Jee and Eun (2011) highlight how the Chinese catch-up model differs from that of the rest of East Asian countries with the following features: i) parallel learning from FDI, ii) university spin-offs, and ii) acquisition of technology through mergers and acquisitions (M&As). Although there are similarities between the policies of China and the East Asian tigers, such as policies facilitating export orientation, protection of local firms and strengthening education and science, there is also an apparent deviation, especially in the ones influencing technology transfer from abroad. This suggests that catching-up economies may have different models in developing technological capabilities with varying degrees of dependence on global knowledge sourcing in the catch-up process.

We speculate that the difference in industrial policy during the catch-up process may have influenced the level of global connectivity in knowledge production in South Korea and China. Before showing the evidence of the diverging pattern in the utilisation of foreign knowledge in innovation in the two countries, we compare the relevant government policies for technological catch-up of South Korea and China since the 1960s. We divide the policies into i) those related to creating opportunities for global knowledge transfer and ii) those related to enhancing local capability building. This division roughly falls into the category of industrial policy and science and technology (S&T) policy, respectively. We argue that these policies, in combination, have created an environment for organisations to develop certain patterns in knowledge creation in the historical context of the two countries. Therefore, it is difficult to single out individual policies as an influential factor for the development of the innovation pattern in the two countries. Nevertheless, we aim to point out some factors by highlighting the difference in government intervention of the two countries during the catch-up.

Table 1 summarises the industrial policy that could have influenced opportunities for global knowledge transfer. In the 1960s, the South Korean government aimed at promoting import-substituting industries and used policy tools such as import restrictions, tax incentives, and custom rebates for this purpose (Amsden 1992; Sakakibara and Cho 2002). Later, the focus moved to promoting export-oriented industries and the government took on the role of shaping the industry structure with entry restrictions, export quotas, and allocation of product lines among incumbents. In promoting export industries, the government encouraged the export of final goods, which required massive importation of foreign capital goods. Initial knowledge transfer from abroad mainly occurred through capital goods imports, reverse engineering and turnkey projects as the South Korean government restricted both inward FDI and foreign licensing (Amsden 1992; Ahn 2001). The learning involved in this process was mainly from codified knowledge with limited direct interaction and collaboration with foreign actors.

Since the early catch-up period, the South Korean government has had a targeted industrial policy, picking out strategic industries and providing diverse forms of political support to develop these industries. In the 1970s, the focus moved from light industries (LI) to heavy and chemical industries (HCI) as can be seen from the HCI promotion plan, which declared steel, shipbuilding, machinery, electronics, non-steel metal, petroleum and chemical industries as strategic industries. These industries received preferential loans, entry regulations, selective protection and corporate tax deductions (Mah 2007). In the 1980s, the government realised the importance of R&D for long term economic development and chose strategic industries where new emphasis was placed on R&D. Semiconductor, automotive, shipbuilding, metal, and small-sized aircraft were the new industries in focus. Later in the 1990s, the focus moved to the high value-added capital goods industry, and the information technology (IT) industry received a large share of governmental R&D expenditure. In the late 1990s, the following six technologies were chosen as key technologies to develop a knowledge-based society: IT, biotechnology, environment technology, culture technology, nano technology, and space technology (Mah 2007).

Table 1. Industrial policy related to global knowledge transfer

South Korea		China	
Policy	**Implication**	**Policy**	**Implication**
The 1960s: Import substitution policy, Inward FDI restriction, Focus on labour intensive industries	• Knowledge sourcing through importation of foreign capital goods and licensing	The 1970s-1980s: Allowing inward FDI, Amending JV law, Export processing zones, Industrial high-tech park hosting both foreign and local firms	• High level of inward FDI & international JV, leading to increased opportunities for collaboration with foreign firms
The 1970s-1980s: Export promotion policy, Transition to heavy and chemical industries, Function-oriented support for R&D, Support for the growth of *chaebols*	• Reverse engineering as a learning mechanism • Limited knowledge transfer from inward FDI • Emergence and growth of large diversified business groups, called *chaebol*	The 1990s-2000s: More active FDI policy (opening for more industries)	• Local firms' integration into GVCs as a production platform for foreign firms
The 1990s-2000s: Focus on selected industries such as IT, green, and biotech industries, Relaxing the restriction on FDI	• Private-led R&D efforts by *chaebols*	The 2000s: High-tech-sector-oriented policy, Local content requirement, Outward FDI with 'Go global' policy	• Foreign firms' integration to local setting in high-tech • Direct access to foreign technology through investment abroad • Acquisition of strategic assets through M&A

Source: Authors' creation based on Howell 2018, Li, Li and He 2018, Mah 2007, Sakakibara and Cho 2002.

The strategic industrial focus together with other policy instruments such as import substitution and export promotion facilitated the emergence, diversification and growth of *chaebols*[1] in the selected areas (Amsden 1992). Although direct government investment in R&D was limited to 20 per cent of the total South Korean R&D expenditure in the 1990s (Sakakibara and Cho 2002), *chaebols* that enjoyed monopolistic rent under the government policy restricting new entrants and imports drove the majority of R&D spending. Owing to substantial financial support from the government, the *chaebols* were able to rapidly build and upgrade their competences by conducting internal R&D (Hobday 1995). Moreover, the government funded large-scale research consortia, in which major *chaebols* participated and developed technological knowledge further.

Throughout the catch-up period, the South Korean government had restricted inward FDI while supporting the formation of a few business groups, thus, foreign firms had little presence in the economy (Baek 2005). Even though the South Korean government had revised its FDI policy first in 1996 and again in the early 2000s by removing policy barriers to inward FDI, this movement occurred first after intense catch-up had taken place. There were still barriers against foreign ownership in 26 industries after revisions to the policy (Jones and Yoon 2008).

In contrast to South Korea's industrial policies focusing on local firms' capability building, China's policy directed attention towards opening up the economy. From the 70s, the Chinese government had an economic "open-door" policy and started facilitating technology transfer in the form of the purchase of turnkey plants and equipment, licensing, technical consulting, and co-production. In contrast to South Korea, which had restrictions on inward FDI (Fu, Woo, and Hou 2016), China implemented a package of institutional changes to attract FDI, expecting the beneficial spillover effects of FDI to facilitate the technological progress of domestic firms. The establishment of the first special economic zones (SEZs) in 1980 supported the facilitation of inward FDI. Special Economic Zones and high-tech industrial parks were created to encourage the collocation of foreign firms and local firms. The instruments used for attracting FDI were tax incentives, foreign exchange provision, land use, and licencing procedures (Li, Li and He 2018). The reform of FDI policy in the 1990s increased the pace of foreign capital inflows, and the further amendment of regulations in the 2000s opened up a broader range of industries for FDI. Consequently, China has been the largest recipient of FDI among developing economies since the late 1990s, and more than 80 per cent of FDI in China since 1978 have arrived on the basis of the principle of "trading market for technology" especially in industries such as automotive, chemicals, and electronics (Xie and Wu 2003).

[1] Large family-owned conglomerates.

Furthermore, the government policy also encouraged the establishment of joint ventures between foreign firms and local firms, expecting “low-cost” technology transfer in the local market (Howell 2018), creating linkages between foreign and local firms (Fu, Pietrobelli, and Soete 2011). The collaboration among foreign and local firms induced by the government regulations has been critical for local firms in getting access to foreign knowledge in sectors such as mobile telecommunication and automotive (Mu and Lee 2005; Lee, Cho and Jin 2009). The local firms in the automotive and electronics sectors benefited greatly from a market protection policy with regulated import and entry, equity restrictions on foreign firms in joint ventures (JVs) and local content requirements. Even though China had a targeted policy towards certain strategic industries as South Korea did, the focus was on promoting technology transfer through inward FDI and the establishment of JVs as a mechanism for fostering these industries.

Since the early 2000s, the government relaxed the regulations on outward FDI and encouraged Chinese firms to “Go Global”, which led to a surge in the outflow of FDI and M&As between Chinese and foreign firms (Lee, Jee and Eun 2011). While earlier M&As aimed to get access to natural resources and markets, more recent M&As had the purpose of acquiring managerial know-how, brand recognition and technologies. In addition to joint ventures, the outward FDI also provided opportunities for direct technology transfer from abroad. The government also offered the procurement of development funds and supported firms with self-reliant operations and self-developed products (Lee, Cho and Jin 2009). All this effort allowed China to become a manufacturing hub for the global market, which meant that local firms integrated well into GVCs as a production platform for foreign firms. Compared to South Korea, the mix of these industrial policies facilitated direct interaction and collaboration between local and foreign entities.

While the general industrial policy shaped the channels and mechanisms for foreign knowledge sourcing in the process of catch-up, S&T policy complemented this process by establishing the foundation for local competence building. Table 2 shows how S&T policy has unfolded since the 1960s in the two countries.

South Korea started to create S&T infrastructure, including the establishment of relevant ministries and scientific education in the 1960s in parallel with the strategic promotion of automotive, shipbuilding, mechanical engineering and electronics industry (Chung 2003). The strategic focus on these industries and the import substitution policy necessitated the development of local technological competences. As industrial policy turned toward the promotion of heavy, chemical and export-oriented industries in the 1970s, the government also saw the need to found government-funded research institutes (GRIs). However, the R&D promotion of the government had not started until the 1980s. In the 1980s, significant technological capability building took place through the

National R&D Programmes, supporting joint projects involving both private and public actors in key focus sectors such as the electronics and information industries.

Building on the rapid increase in industrial R&D capabilities in the private sector, the South Korean government tried to increase national R&D expenditure throughout the 1990s. The focus was also on enhancing the capabilities of universities in producing scientific knowledge by initiating the Excellent Research Center programme for universities (Chung 2003). At the turn of the century, the government formulated the Basic Law of Science and Technology to aim for a systematic promotion of science and technology. Vision 2025 as a long-term plan for science and technology development was adopted and provided the basis for the development of the five-year S&T plans.

China actively started formulating S&T-related policies to build local competences from the 1970s. The government held the National Science Conference in 1978, realising the need to restore key S&T organisations and technological capabilities. The most notable policy in the 1980s was the Chinese People's Political Consultative Conference (CPPCC)'s decision to reform China's S&T system. This decision was followed by the initiation of S&T programmes such as the State High-Tech R&D Programme (1986), High Tech Research and Development Plan (known as the 863 programme), and Torch programme (Fu, Woo and Hou 2016).

From the late 1980s to the 1990s, the effort to revitalise the S&T system was accompanied by the enactment of several laws including S&T-related laws such as the Patent Law (1985), the Law on the Progress of Science and Technology (1993), and the Law on Anti-Unfair Competition (1993) and other laws nurturing the business environment in general. The government also initiated projects to enhance the local knowledge base. The "211" project aimed to strengthen research and teaching capability of 100 key universities, and another initiative "Invigoring the Country through Science and Education Strategy" was designed to increase the spending on education (Lee, Jee and Eun 2011). During the same period, the State Council approved setting up national high-tech parks, including the Zhongguancun Science Park, to support high-tech start-ups that spun off from the research institutes and universities. The Ministry of Science and Technology was established in 1998 to ensure that the government receives professional input when formulating S&T policy.

From the 2000s and onwards, certain key technologies and industries have been identified to indicate strategic priorities towards these sectors. It is also evidenced by the number of sectoral policy programmes that have increased significantly during this period. Moreover, direct government expenditure on S&T projects has increased as the government launched 16 megaprojects. In line with this, a noticeable policy direction in this period is shown in the effort made to promote domestic R&D rather than to import technology (Chen and Naughton 2016).

Table 2. S&T policy related to local technological competence building

<table>
<tr><th colspan="2">South Korea</th><th colspan="2">China</th></tr>
<tr><th>Policy</th><th>Implication</th><th>Policy</th><th>Implication</th></tr>
<tr><td>The 1960s:
Establishment of Korea Advanced Institute of Science and Technology (KAIST) & Ministry of Science and Technology (MOST) established,
Beginning of scientific education</td><td>• Establishment of relevant public organisations such as ministries and research institutes</td><td>The late 1970s and 1980s:
Revitalisation of S&T programmes,
Enacting various laws including patent law (continued in the 1990s)</td><td>• Establishment of relevant public organisations such as ministries and research institutes</td></tr>
<tr><td>The 1970s:
Establishment of government research insitutes (GRIs) to give firms access to technology</td><td>• Focus on education, mass-production of engineers, scientist, and R&D personnel</td><td>The 1990s:
More S&T and R&D programmes to build R&D infrastructure,
Establishment of Ministry of Science and Technology (MOST),
Increasing investment in higher education,
Approval to establish national high-tech parks</td><td>• Establishment of formal institutions relevant for technological capability building</td></tr>
<tr><td>The 1980s:
Various R&D consortia formed under Industrial Research Association,
Big R&D projects in strategic industries like electronics and information technologies</td><td>• Local level collaboration in research projects, involving both public and private actors.
• Supported chaebol's (private) R&D efforts</td><td rowspan="3">The 2000s:
Sector-specific policy,
Increasing R&D expenditure as the share of GDP, Focus on production of scientific knowledge, Foreign education and training</td><td rowspan="3">• Investment in the local education system as well as sending a large population to study and train abroad
• Dedicated effort to enhance local technological knowledge</td></tr>
<tr><td>The 1990s:
Expanding R&D expenditure and support for academic innovation</td><td rowspan="2">• Systemic coordination of science and technology policy
• Increasing focus on academic innovation and industry-university collaboration</td></tr>
<tr><td>The 2000s:
Basic Law of Science and Technology,
New focus on green technologies</td></tr>
</table>

Source: Authors' creation based on Chung 2003, Dahlman 2009, Sakakibara and Cho 2002, Karo 2018, Liu et al. 2011, Chen and Naughton 2016.

China has also focused on expanding the tertiary education system since the late 1990s, which is reflected in the gross enrollment ratio[2] of 51 per cent in the tertiary education in 2018 (The World Bank, 2020). Apart from investment in the domestic education system, China also sends a substantial number of tertiary-level students abroad for education and training (Dahlman 2009).

To sum up, both countries have invested heavily in creating local technological competence through various S&T policy initiatives, including the establishment of formal institutions and the development of the educational system during the last decades. Where we could see the marked difference is the general industrial policy that creates opportunity and incentive for interaction with foreign actors. China has implemented more purposeful policy initiatives to induce technology transfer from foreign actors than South Korea, which focused more on providing support to fostering a selected group of firms and industries through import substitution and export promotion policy.

5. The openness of innovation activities in South Korea and China

As explained above, the industrial policies of South Korea and China during the catch-up period have facilitated diverging mechanisms for technology transfer and led eventually to the development of different industrial structures, the demography of firms and global business relations in the two countries. We postulate that this development, as an outcome of industrial policy, has contributed to the emergence of different innovation patterns in the two countries in terms of how open they are towards foreign sources of knowledge. In this section, we show the difference in the openness of the innovation activities of the two countries, measured by the degree of international collaboration and reliance on local and foreign knowledge in patenting. While presenting the results on the patent analysis, we draw a parallel between the openness of innovation activities and industrial policies in the two countries.

5.1. Data and method

To analyse the degree of international collaboration and reliance on local knowledge in knowledge creation in the two countries, we conducted a patent analysis. Our patent data comes from the patent statistical database, Patstat Global (version 2018b), created and maintained by the European Patent Office (EPO) (EPO 2019).

[2] Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown.

This database contains bibliographic information of applications and publications of patents from patent offices in the leading industrialised and developing countries. Despite some criticism for using patents as a measure for innovation, patents are known to represent firms' inventive activity, and thus, are frequently used for the analysis of the process of technological change and development (e.g., Griliches 1998). We see patent documents as formal documentation of technological knowledge creation and take the geography of inventor location to represent the locality of knowledge creation.

Our analysis unit is a unique patent family, which may contain several different applications filed in various national patent offices over time. We include all patent families from all patent offices registered in Patstat as we aim to capture all knowledge creation activities regardless of the quality of patents. We identify South Korean and Chinese patents as patents that have at least one inventor located in the country as we emphasise the actual knowledge generation taking place in the two countries (Lee, Mudambi and Cano-Kollmann 2016). We focus on innovation activities of firms since firms are the primary engines for the economic development of a country (Porter 1990) and the main actors creating knowledge in innovation systems. We constructed our dataset, which consists of patents that were filed by at least one firm applicant in the two countries, for the period between 1975 and 2017. This timeframe captures periods of intense technology catch-up for both South Korea and China. We did patent analysis across all main technology-intensive industries[3] such as electronics, chemical, pharmaceutical, machinery, and transportation to show that the knowledge-sourcing pattern is consistent across all industries regardless of the degree of technological complexity of the focal industry. Following this identification strategy, 390,816 Chinese patents and 1,192,597 South Korean patents are included in the data[4].

5.2. Analysis and results

First, we looked at the level of international collaboration among the inventors of patents in five industries (See Figure 1). To measure this, we calculate the share of local patents created based on international collaboration: the percentage of the patents with at least one inventor located abroad. International collaboration on patenting serves as an important channel for international knowledge transfer and

[3] Industry categorisation follows European statical classification of economic activities, NACE (Nomenclature of Economic Activities) codes by EPO constructed based on the International Patent Classification system (IPC).

[4] About 19 per cent of Chinese and and 21 per cent of South Korean patents are either not in the industries of our interest for the analysis or missing the information on industry. These patents were excluded from the analysis. We also note that sorting out non-firm applicants also reduced the total number of patents included in the analysis.

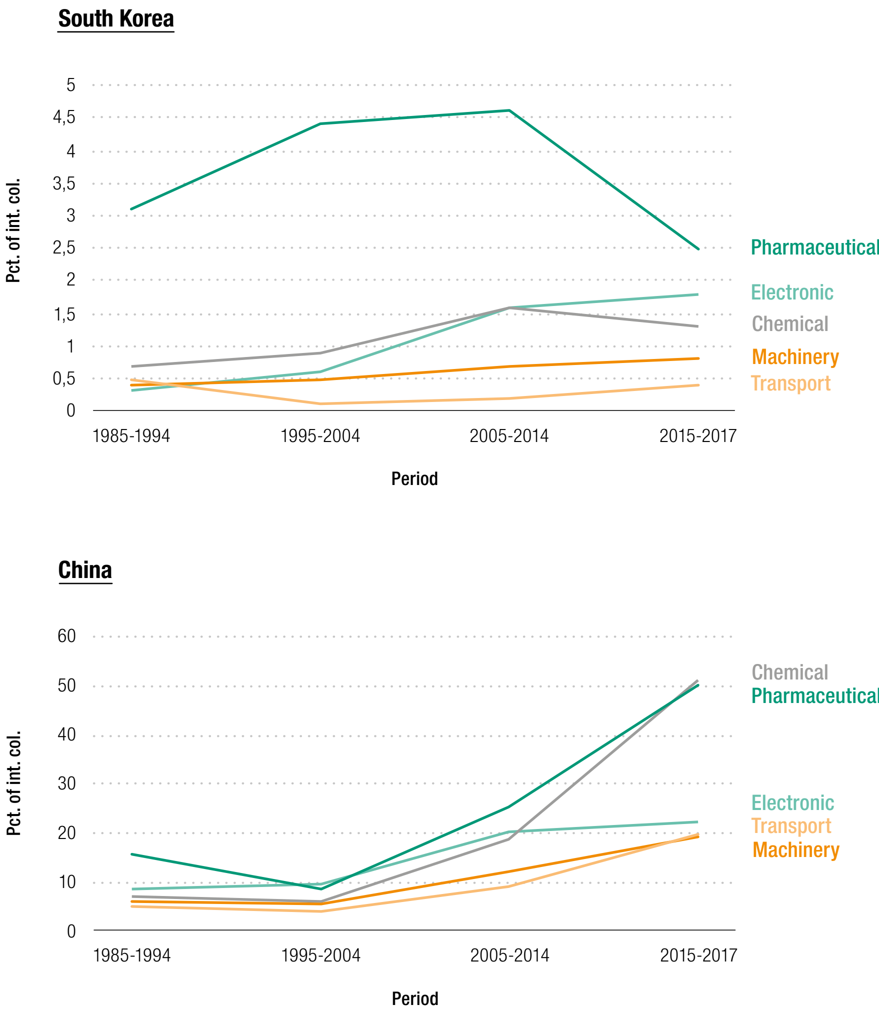
diffusion through personal interaction (Guan and Chen 2012; Giuliani, Martinelli and Rabellotti 2016). From the perspective of catch-up economies, frequent international collaboration on patenting indicates more reliance on foreign knowledge when creating new knowledge. We found that, on average, the percentage of international collaboration of South Korean patents is 1.52, whereas for Chinese patents it is 16.89. South Korean inventors show much less collaboration with foreign actors than do Chinese inventors, which seems to support our expectation that South Korean patents rely more on local knowledge source than Chinese patents.

By industry, in the case of South Korean patents, the percentage of international collaboration is 1.3 (electronics), 1.4 (chemical), 4.1 (pharmaceutical), 0.6 (machinery), and 0.2 (transportation), respectively. In the case of Chinese patents, the percentage of international collaboration is 18.2 (electronics), 15.4 (chemical), 20.0 (pharmaceutical), 11.0 (machinery), and 9.4 (transportation), respectively. We find a stark difference in the international collaboration level of the two countries. This tendency is consistent throughout the whole period of investigation (1975-2017). When we break the whole period down into 10-year periods, we notice that the level of international collaboration on South Korean patents increases at a slower rate compared to the Chinese patents, which show a huge increase in the shares in all industries. Even when considering the lag between the catch-up periods of the two countries, we observe a consistent divergence in the level of international connectivity in patenting.

The diverging pattern is most evident in the electronics industry, and this seems to be attributed to more focused government policies in terms of limiting or increasing foreign presence in this industry. In 1972, the South Korean government implemented the third five-year plan (i.e., the Heavy Chemical Industrialisation Plan) and identified the electronics industry as one of the strategic industries deemed important for national security (Moreira 1995; Kojima 2000; Ahn 2001). The primary concern for the South Korean government was to achieve independence from foreign influence and create internationally competitive local companies (Hannigan, Lee and Mudambi 2013). The government encouraged the acquisition of foreign technologies mainly through the import of capital goods, reverse engineering and turnkey projects, while restricting inward FDI (Ahn 2001). Furthermore, the government policy to support a few selected firms through public loans enabled the formation of the large business groups and encouraged their fast expansion through diversification (Ahn 2001; Sakakibara and Cho 2002), in which FDI had little importance (Baek 2005).

Similarly, the Chinese government also identified the electronics industry as a strategic industry, but the Chinese policy is distinguished by the government's emphasis on attracting FDI, making the electronics industry the top recipient of foreign investment since 1999 (Zhao et al. 2007). Furthermore, although the Chinese government supported the formation of big business groups, Chinese business groups, unlike *chaebols*, are formed and expanded through the horizontal merger of similar firms (Baek 2005). The development path of Chinese business groups, therefore, may not have led to the same level of internal knowledge and technology building but instead has increased reliance on other firms in knowledge creation.

Figure 1. International collaboration on patenting (1985–2017)



Source: Authors' analysis of PATSTAT Global data.

To dig more in-depth into the tendency and the degree of international collaboration on knowledge creation in both countries, we looked at global interaction at applicant level[5], which allows us to capture some cases that may not be captured by looking at the inventor level only. Such cases are: i) Co-filing of the patent by the foreign applicant(s) and the local applicant(s), in which all inventors are located in one country (foreign and local applicants with no international collaboration in Table 3); ii) The international collaboration between local inventors and foreign applicants that could represent innovation activities by a local subsidiary of a foreign multinational firm (foreign applicants only with no international collaboration in Table 3). All of these mentioned above are important cases that should not be missed if one is to capture the degree of international collaboration in the creation of new knowledge in a country because foreign multinationals provide pipelines that give access to foreign knowledge (Kogut and Zander 1993).

As seen in Table 3, on average, the number of patents filed by local applicant(s) only is much higher in South Korean patents (96.09 per cent) than in Chinese patents (79.04 per cent), which is consistent across all industries. By contrast, the number of Chinese patents filed by foreign applicant(s) only, and jointly by foreign and local applicant(s), is much higher than that of South Korean patents, which indicates the significant foreign presence in knowledge creation in China compared to Korea. Specifically, the higher share of patents by co-filing of foreign and local applicants in China could be the result of JV policy.

Aside from the main observation that foreign presence in knowledge creation is much higher in China compared to South Korea, what we found interesting was that the share of patents with international collaboration among the patents filed by foreign applicants only was significantly higher for Chinese patents. This tendency is consistent across all industries. We interpret that as the influence of China's "trading market for technology" policy to attract foreign firms. Unlike the South Korean market, China with its considerable market potential stemming from high growth rate and its vast population must have been considered very attractive from investors' perspective. When China opened up the domestic market, foreign multinationals must have entered China with a clear "home-base-exploiting" purpose (Kuemmerle 1999). It may have induced foreign firms to create new knowledge in close collaboration with both local and foreign actors to develop "localised" products based on existing knowledge within the firm.

Then, to understand where collaborating inventors originate from, we looked at the composition of the country of collaborating inventors (see Appendices). We show the top five country locations of inventors that appear in the investigated

[5] Due to missing values for location data for applicants, the total number of patents included in this further analysis is reduced to 1,155,554 (South Korea) and 390,195 (China).

patents and calculated the share of inventors from each country out of the total number of inventors. Similar to the results above, South Korean patents showed the tendency to source knowledge locally compared with Chinese patents, as the percentage of inventors originating from the home country is much higher for South Korean patents (95.81-99.74 per cent) than for Chinese patents (68.04-90.99 per cent). Both countries rely highly on inventors in the United States as collaborating partners. Japan also frequently appears as a collaborating partner, but the relative importance of Japanese inventors seems to be higher for South Korea than for China. For China, Taiwan appears to be influential for knowledge creation in the electronics and machinery industry. This can be understood as a result of a unique development process that China went through based on the tie to Taiwan. Our results confirm Saxenian's (2006) explanation that China leveraged the resources of Taiwan and actively utilised the connection Taiwan has with the United States (Silicon Valley) in technological capability building, particularly in the semiconductor and ICT industries. The relative importance of neighbouring countries as collaborators also suggests that the two countries depend on other Asian countries that industrialised earlier than them in innovation activities.

Table 3. International collaboration on patenting at applicant level (1975–2017) (continued)

	Applicant							
	South Korea				China			
Inventor	**Foreign only**	**Local only**	**Foreign & local**	Total	**Foreign only**	**Local only**	**Foreign & local**	Total
Electronics								
No international collaboration	19,861 (84.63%)	689,387 (99.35%)	1,955 (66.79%)	711,203	23,840 (40.48%)	170,219 (98.66%)	9,682 (54.56%)	203,741
International Collaboration	3,606 (15.37%)	4,446 (0.65%)	972 (49.71%)	9,024	35,051 (59.52%)	2,317 (1.34%)	8,064 (45.44%)	45,432
Total	23,467 (3.38%)	693,833 (96.33%)	2,927 (0.04%)	720,227	58,891 (23.63%)	172,536 (69.24%)	17,746 (7.12%)	249,173
Chemical								
No international collaboration	1,723 (77.16%)	70,562 (99.46%)	136 (59.91%)	72,421	1162 (17.08%)	34563 (99.26%)	256 (29.19%)	35,981
International Collaboration	510 (22.83%)	382 (0.54%)	91 (40.08%)	983	5642 (82.92%)	256 (0.74%)	621 (70.81%)	6,519
Total	2,233 (3.04%)	70,944 (96.64%)	227 (0.32%)	73,404	6,804 (16.0%)	34,819 (81.92%)	877 (2.08%)	42,500

Table 3. International collaboration on patenting at applicant level (1975–2017) (concluded)

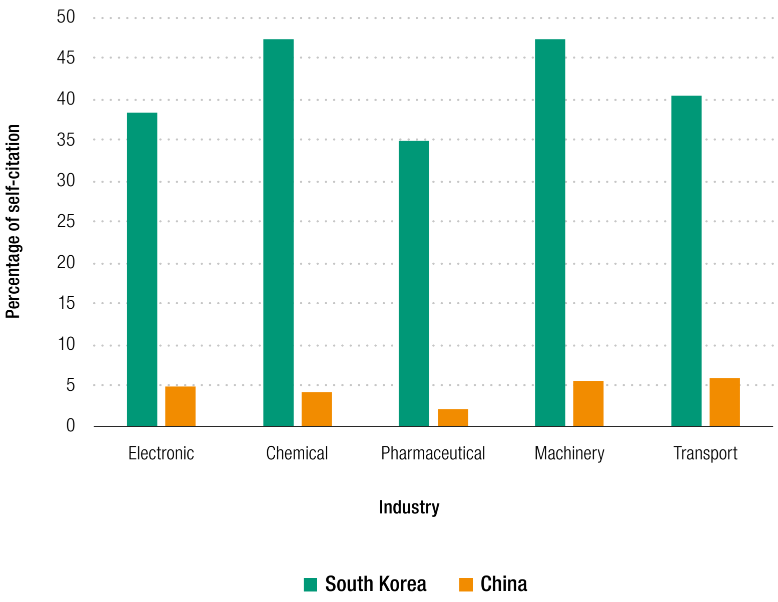
	Applicant							
	South Korea				China			
Inventor	**Foreign only**	**Local only**	**Foreign & local**	Total	**Foreign only**	**Local only**	**Foreign & local**	Total
Pharmaceutical								
No international collaboration	832 (59.89%)	20,346 (98.91%)	104 (57.45%)	21,282	446 (6.93%)	26880 (98.82%)	115 (17.45%)	27,441
International Collaboration	557 (40.11%)	223 (1.09%)	77 (42.55%)	857	5994 (93.07%)	321 (1.18%)	544 (82.55%)	6,859
Total	1,389 (6.27%)	20,569 (92.90%)	181 (0.83%)	22,139	6,440 (18.77%)	27,201 (79.30%)	659 (1.93%)	34,300
Machinery								
No international collaboration	6,062 (90.35%)	238,322 (99.66%)	326 (68.05%)	244,710	3216 (41.82%)	47188 (99.16%)	1631 (51.16%)	52,035
International Collaboration	647 (9.65%)	804 (0.34%)	153 (31.95%)	1,604	4475 (58.18%)	402 (0.84%)	1557 (48.84%)	6,434
Total	6,709 (2.72%)	239,126 (97.08%)	479 (0.20%)	246,314	7,691 (13.15%)	47,590 (81.39%)	3,188 (5.46%)	58,469
Transportation								
No international collaboration	1,515 (94.45%)	91,689 (99.87%)	47 (73.43%)	93,251	398 (50.06%)	4748 (98.96%)	68 (42.5%)	5,214
International Collaboration	89 (5.55%)	113 (0.13)	17 (26.57%)	219	397 (49.94%)	50 (1.04%)	92 (57.5%)	539
Total	1,604 (1.71%)	91,802 (98.22%)	64 (0.07%)	93,470	795 (18.81%)	4,798 (83.39%)	160 (2.80%)	5,753

Source: Authors' analysis of PATSTAT Global data.

As a final step, we conducted a self-citation analysis. We calculated the *share of self-citation based on inventor countries present in backward citation* to show to what extent the previously existing local and foreign knowledge is utilised respectively in new knowledge creation (Lee, Szapiro and Mao 2018). We consider the country locations of inventors of all backward citation of the patents in the study and calculate the share of inventors from the two countries out of the total number of inventors of backward-citation patents[6] (results presented in Figure 2). Compared to the first measure that shows the level of direct international collaboration in "contemporary" innovation activities, this measure shows the geographical distribution of "past" knowledge that could have influenced new knowledge creation.

As seen in Figure 2, our self-citation analysis further confirms that South Korean patents show much more reliance on previously existing local knowledge when it comes to creating new knowledge than do Chinese patents. Although both countries have high numbers of patents cited that originate from the US, the share of self-citation is much higher (range between 35 and 48 per cent) for South Korean patents than for Chinese patents (range between 2 and 5 per cent).

Figure 2. Share of self-citations (1975–2017)



Source: Authors' analysis of PATSTAT Global data.

6 We did not deduplicate backward citations because each backward citation associated with a focal patent counts for one source of knowledge sourcing. Since our purpose is to show the share of self-citations in the total backward citations in the two countries, we only provide the top five countries where backward citations originate from.

By breaking this down into 10-year periods, we notice that South Korean patents' reliance on local knowledge increased exponentially over time, which was consistent across all the industries we studied[7]. By contrast, the share of self-citation in Chinese patents is much lower than that of South Korea and increased rather slowly over time in all industries. However, the share of self-citation may reflect the level of the technological knowledge stock that exists in the country. Since South Korea's catch-up precedes China's[8], South Korea had more time to accumulate domestic knowledge stock to utilise in new knowledge creation. Even when we consider a time lag due to the different developmental stages of China and South Korea, the increasing rate of self-citation in China still seems to be very small in the most recent period.

6. Concluding remarks and policy recommendations

This paper presents findings that suggest the possible impact of FDI and industrial policies during the catch-up periods on the openness of local knowledge creation in the two East Asian countries, South Korea and China. Our analysis shows that, compared to Chinese patents, South Korean patents were created based on a lower level of international collaboration, and new knowledge was created through patenting that relied to a greater extent on local sources of knowledge. This divergent pattern of innovation in the two countries continues to exist even after the catch-up periods, which suggests that South Korea's innovation system is more closed compared with the Chinese innovation system. We postulate that this pattern could be attributed to different industrial policies, especially different FDI policies, during the catch-up processes in these two countries.

The openness of innovation activities, which we speculate to be one outcome of industrial policies, may have different implications for the two economies. China can utilise global connections to get access to diverse sets of knowledge, which is critical to increase the chance of generating noble innovation (Bierly and Chakrabarti 1996; Rosenkopf and Almeida 2003). However, for China, having an open innovation system also means a high dependency on foreign knowledge in their innovation activities, which can interfere with building up the indigenous knowledge base (Liu et al. 2017). On the contrary, the independent, but closed innovation system of South Korea may lead to lock-in, where firms have limited opportunities to gain new sources of knowledge to be able to diversify and renew their existing knowledge.

[7] Further details on self-citation analysis can be provided upon request.

[8] China is in a different developmental stage compared with South Korea and Taiwan as it was included in the international division of labour within East Asia first in the 1990s (Hobday 1995). One of the ways Lee, Jee and Eun (2011) determine "technological catch-up"is to see whether residents' patenting catches up with non-residents' patenting, and according to this measure, there is approximately a ten-year gap between South Korea (1993) and China (2003).

We show that innovation capability in developing economies can be shaped by a broad range of government policy, not only by innovation (S&T) policy. Developing economies tend to focus less on fostering innovation activities since the immediate economic gain can be obtained through other economic activities. It also takes time for them to develop a certain level of technological capability that is required for conducting innovation activities (Awate, Larsen and Mudambi 2012). Our results seem to suggest that the effort to boost immediate economic growth in the catch-up process can also influence the development of the innovation system. Thus, this research calls for a systematic approach to policymaking for developing innovation systems.

With regards to technological catch-up, we demonstrate that there is no one "best" catch-up model that works for all by comparing the different catch-up processes of South Korea and China. Although there have been development models like the "Flying geese model" and "developmental state" that emphasise similarities in the industrial development of "East Asian tigers" (i.e., Hong Kong, Singapore, South Korea and Taiwan), a more recent discussion in the literature points out that each country has a unique economic and institutional setting and thereby needs nuanced government policies to support the idiosyncratic catch-up process (Mytelka 2006). We provide evidence supporting this view by highlighting the difference in industrial policy that induces different types of technology transfer and different levels of global collaboration on innovation activities. It is worth noting that China, as a "late" follower in the region, has shown a distinctive development path compared to the "East Asian tigers", especially South Korea and Taiwan (Xie and Wu 2003; Lee, Jee and Eun 2011).

Based on our findings, we propose some recommendations for policymakers. First of all, policymakers need to formulate industrial policies with a long term perspective. The way that firms become connected to the global economy will have a long-lasting effect on the sustainability of economic development. Once firms have formed their connection to the global economy, it may be difficult to change the pattern of interaction afterwards, leading to too much or too little dependency on the foreign actors in their economic activities. As this interaction pattern can influence how latecomer economies innovate in the long run, it is of utmost important not to solely pursue short-term gains that may lead to unfavourable conditions for the development of innovation capabilities.

Second, it is vital to acknowledge the interdependency between trade-related industrial policies or investment policies and knowledge sourcing or the creation activities of local firms. Trade-related policies such as import substitution and FDI policies seem to influence how knowledge is sourced, utilised and generated in the interaction between local and foreign firms. Striking the right balance between the degree and the types of global interaction is critical in developing technological capabilities as a latecomer and consequently generating local innovation beyond imitation. It also suggests that investment policies need to be considered an important element of industrial policies for sustainable economic development for less-developed economies as highlighted in the UNCTAD's investment policy framework for sustainable development (2015) and the World Investment Report (2018). Policies promoting foreign investment in the local economies may induce a spillover effect for industrial development through the development of a knowledge transfer and knowledge creation pattern. Latecomer economies should, furthermore, design policies that strengthen local capability building alongside adequate industrial and investment policies in order to facilitate sustainable economic development. Regardless of the types of interaction created in the global setting, independent local technological capabilities are critical for creating continuous development. As our review of the S&T policies of South Korea and China shows, both countries have developed local technological capabilities through the establishment of the education system and relevant public institutions, which emphasises the importance of independent local technological capabilities regardless of the direction of the FDI policies in these countries.

One future avenue to explore is to see if this link between trade-related industrial policies and innovation pattern is observed in other countries. While we acknowledge that industrial policies are born in response to a specific economic, institutional, and social context in an economy, which limits the generalisation of our finding, it would be interesting to study if industrial policy has a similar impact on innovation in other economies. To contextualise how industrial policies may influence the degree of international collaboration in innovation systems, one could also analyse the nature of international collaboration in patenting activities and the nature of knowledge generated through such collaboration. While we could detect the degree and the basic composition of international collaboration in patenting activities in our analysis, we do not know the exact nature of such collaborations due to the limitations of our data.

Specifically, incorporating the data on the operations of MNEs in host economies could shed light on the possibility of local firms engaging in international collaboration in innovation activities. For example, the two different types of subsidiary mandates from the headquarters i.e., competence-exploiting vs. competence-creating mandate (Cantwell and Mudambi 2005), can influence the possibility of establishing collaboration between local and foreign firms. Unlike subsidiaries with a competence-exploiting mandate, subsidiaries with a competence-creating mandate may engage in a rather intensive collaboration with local firms since they intend to create new knowledge distinctive from the MNE's existing knowledge repository. By exploring this further, we expect to be able to understand better the impact of industrial policy on shaping different knowledge sourcing patterns in countries.

References

Abramovitz, Moses. 1986. "Catching Up, Forging Ahead, and Falling Behind." *The Journal of Economic History* 46 (02): 385-406. http://doi.org/10.1017/S0022050700046209.

Ahn, Choong Yong. 2001. "A Search for Robust East Asian Development Models After the Financial Crisis: Mutual Learning from East Asian Experiences." *Journal of Asian Economics* 12 (3): 419-443. https://doi.org/10.1016/S1049-0078(01)00095-1.

Amsden, Alice Hoffenberg. 1992. Asia's Next Giant: South Korea and Late Industrialization. Oxford University Press on Demand. https://doi.org/10.1093/0195076036.001.0001.

Awate, Snehal, Marcus M. Larsen and Ram Mudambi. 2012. "EMNE Catch-Up Strategies in the Wind Turbine Industry: Is there a Trade-Off between Output and Innovation Capabilities?" *Global Strategy Journal* 2 (3): 205-223. http://doi.wiley.com/10.1111/j.2042-5805.2012.01034.x.

Baek, Seung-Wook. 2005. "Does China Follow "the East Asian Development Model"?" *Journal of Contemporary Asia* 35 (4): 485-498. https://doi.org/10.1080/00472330580000281.

Barnes, Justin and Mike Morris. 2008. "Staying Alive in the Global Automotive Industry: What can Developing Economies Learn from South Africa about Linking into Global Automotive Value Chains?" *European Journal of Development Research* 20 (1): 31-55. https://doi.org/10.1080/09578810701853157.

Bell, Martin and Keith Pavitt. 1992. "Accumulating Technological Capability in Developing Countries." *The World Bank Economic Review* 6 (suppl 1): 257-281. https://doi.org/10.1093/wber/6.suppl_1.257.

Berry, Heather. 2014. "Global integration and innovation: multicountry knowledge generation within MNCs." *Strategic Management Journal* 35 (6): 869-890. https://doi.org/10.1002/smj.2140.

Bierly, Paul and Alok Chakrabarti. 1996. "Generic Knowledge Strategies in the U.S. Pharmaceutical Industry." *Strategic Management Journal* 17 (S2): 123-135. doi:10.1002/smj.4250171111. https://doi.org/10.1002/smj.4250171111.

Branstetter, L. 2006. "Is Foreign Direct Investment a Channel of Knowledge Spillovers? Evidence from Japan's FDI in the United States." *Journal of International Economics* 68 (2): 325-344. https://doi.org/10.1016/j.jinteco.2005.06.006.

Buzdugan, Stephen R. and Heinz Tueselmann. 2018. "Making the Most of FDI for Development:'New'Industrial Policy and FDI Deepening for Industrial Upgrading." *Transnational Corporations* 25 (1): 1-21. https://doi.org/10.18356/bffcf4a5-en.

Cantwell, John and Ram Mudambi. 2005. "MNE competence-creating subsidiary mandates". *Strategic Management Journal 26* (12): 1109-1128. https://doi.org/10.2139/ssrn.289695.

Chen, Ling and Barry Naughton. 2016. *An Institutionalized Policy-Making Mechanism: China's Return to Techno-Industrial Policy* 45 (10): 2138-2152. https://doi.org/10.1016/j.respol.2016.09.014.

Chowdhury, Anis and Iyanatul Islam. 1993. *The Newly Industrializing Economies of East Asia*. Florence: Routledge. https://doi.org/10.4324/9780203976388.

Chu, Wan-wen. 2011. How the Chinese government promoted a global automobile industry, *Industrial and Corporate Change* 20 (5): 1235–1276. https://doi.org/10.1093/icc/dtr010.

Chung, Woojin. 2003. “Innovation in Korea”, *The International Handbook on Innovation*, edited by Larisa V. Shavinina: Elsevier. https://doi.org/10.1016/B978-008044198-6/50062-0.

Dahlman, Carl. 2009. “Different Innovation Strategies, Different Results: Brazil, Russia, India, China and Korea (the BRICKs).” *Innovation and Growth: Chasing a Moving Frontier*: 131-168. https://doi.org/10.1787/9789264073975-9-en.

Deng, Ping. 2007. “Investing for Strategic Resources and its Rationale: The Case of Outward FDI from Chinese Companies.” *Business Horizons* 50 (1): 71-81. https://doi.org/10.1016/j.bushor.2006.07.001.

European Patent Office. 2019. PATSTAT - Data Catalog 2019 Autumn Edition – version 5.14. From: http://documents.epo.org/projects/babylon/eponot.nsf/0/11CE75EDDF734288C125848F0048F533/$FILE/data_catalog_global_v5.14_autumn_2019_en.pdf. Accessed on: 4 November, 2019

Fu, Xiaolan, Carlo Pietrobelli and Luc Soete. 2011. “The Role of Foreign Technology and Indigenous Innovation in the Emerging Economies: Technological Change and Catching-Up.” *World Development* 39 (7): 1204-1212. https://doi.org/10.1016/j.worlddev.2010.05.009 .

Fu, Xiaolan, Wing Thye Woo and Jun Hou. 2016. “Technological Innovation Policy in China: The Lessons, and the Necessary Changes Ahead.” *Economic Change and Restructuring* 49 (2): 139-157. https://doi.org/10.1007/s10644-016-9186-x.

Gereffi, Gary. 1999. “International Trade and Industrial Upgrading in the Apparel Commodity Chain.” *Journal of International Economics* 48 (1): 37-70. https://doi.org/10.1016/s0022-1996(98)00075-0 .

Giuliani, Elisa, Arianna Martinelli and Roberta Rabellotti. 2016. “Is Co-Invention Expediting Technological Catch Up? A Study of Collaboration between Emerging Country Firms and EU Inventors.” *World Development* 77: 192-205. https://doi.org/10.1016/j.worlddev.2015.08.019 .

Griliches, Zvi. 1998. “Patent Statistics as Economic Indicators: A Survey.” In *R&D and Productivity: The Econometric Evidence*, 287-343: University of Chicago Press. https://doi.org/10.3386/w3301.

Guan, Jiancheng and Zifeng Chen. 2012. “Patent Collaboration and International Knowledge Flow.” *Information Processing & Management* 48 (1): 170-181. https://doi.org/10.1016/j.ipm.2011.03.001.

Hannigan, Thomas J., Ahreum Lee, and Ram Mudambi. 2013. “The Pitfalls of an Inward Oriented Economy: Lessons from the Evolution of Brazil and the Republic of Korea.” *Transnational Corporations* 22 (2): 1-24. https://doi.org/10.18356/e10f0502-en.

Hobday, M. 1995. “East Asian Latecomer Firms: Learning the Technology of Electronics.” *World Development* 23 (7): 1171-1193. https://doi.org/10.1016/0305-750x(95)00035-b.

Howell, Sabrina T. 2018. “Joint Ventures and Technology Adoption: A Chinese Industrial Policy that Backfired.” *Research Policy* 47 (8): 1448-1462. https://doi.org/10.1016/j.respol.2018.04.021.

Jones, Randall S. and Taesik Yoon. 2008. "Enhancing the Globalisation of Korea." *OECD Economics Department Working Papers 614*. https://doi.org/10.1787/241606341724.

Khan, Zaheer, Yong Kyu Lew and Pervaiz Akhtar. 2016. "The Influence of Industrial Policy and National Systems of Innovation on Emerging Economy Suppliers' Learning Capability." *Industry and Innovation* 23 (6): 512-530. https://doi.org/10.1080/13662716.2016.1189811.

Kim, Linsu. 1980. "Stages of Development of Industrial Technology in a Developing Country: A Model." *Research Policy* 9 (3): 254-277. https://doi.org/10.1016/0048-7333(80)90003-7.

Kim, Linsu 1999. "Building Technological Capability for Industrialization: Analytical Frameworks and Korea's Experience." *Industrial and Corporate Change* 8 (1): 111-136. https://doi.org/10.1093/icc/8.1.111

Kogut, Bruce and Udo Zander. 1993. "Knowledge of the Firm and the Evolutionary Theory of the Multinational Corporation." *Journal of International Business Studies* 24 (4): 625-645. https://doi.org/10.1057/palgrave.jibs.8490248.

Kojima, Kiyoshi. 2000. "The 'flying Geese' Model of Asian Economic Development: Origin, Theoretical Extensions, and Regional Policy Implications." *Journal of Asian Economics* 11 (4): 375-401. https://doi.org/10.1016/S1049-0078(00)00067-1.

Konara, Palitha and Yingqi Wei. 2017. "Foreign direct investment as a catalyst for domestic firm development: The case of Sri Lanka." *Transnational Corporations* 23 (3): 1-32. https://doi.org/10.18356/a4a49e57-en.

Kuemmerle, Walter. 1999. "The Drivers of Foreign Direct Investment into Research and Development: An Empirical Investigation." *Journal of International Business Studies* 30 (1): 1-24. https://doi.org/10.1057/palgrave.jibs.8490058.

Lall, Sanjaya, John Cantwell and Yanli Zhang. 2009. "The co-evolution of international business connections and domestic technological capabilities: lessons from the Japanese catch-up experience." *Transnational Corporations* 18 (2): 37-68. https://doi.org/10.18356/1be60b89-en.

Lee, Ahreum, Ram Mudambi and Marcelo Cano-Kollmann. 2016. "An Analysis of Japan's Connectivity to the Global Innovation System." *Multinational Business Review* 24 (4): 399-423. https://doi.org/10.1108/mbr-06-2016-0020

Lee, Keun. 2005. "Making a Technological Catch-Up: Barriers and Opportunities." *Asian Journal of Technology Innovation* 13 (2): 97-131. https://doi.org/10.1080/19761597.2005.9668610.

Lee, Keun, Seong-Jae Cho and Jia Jin. 2009. "Dynamics of Catch-Up in Mobile Phones and Automobiles in China: Sectoral Systems of Innovation Perspective." *China Economic Journal* 2 (1): 25-53. https://doi.org/10.1080/17538960902860063.

Lee, Keun, Mansoo Jee and Jong-Hak Eun. 2011. "Assessing China's Economic Catch-Up at the Firm Level and Beyond: Washington Consensus, East Asian Consensus and the Beijing Model." *Industry and Innovation* 18 (5): 487-507. https://doi.org/10.1080/13662716.2011.583463.

Lee, Keun and Chaisung Lim. 2001. "Technological Regimes, Catching-Up and Leapfrogging: Findings from the Korean Industries." *Research Policy* 30 (3): 459-483. https://doi.org/10.1016/S0048-7333(00)00088-3.

Lee, Keun, Marina Szapiro and Zhuqing Mao. 2018. "From Global Value Chains (GVC) to Innovation Systems for Local Value Chains and Knowledge Creation." *The European Journal of Development Research* 30 (3): 424-441. https://doi.org/10.1057/s41287-017-0111-6.

Lee, Keun and Minho Yoon. 2010. "International, Intra-National and Inter-Firm Knowledge Diffusion and Technological Catch-Up: The USA, Japan, Korea and Taiwan in the Memory Chip Industry." *Technology Analysis & Strategic Management* 22 (5): 553-570. https://doi.org/10.1080/09537325.2010.488059.

Li, Zheng, Jun Li and Bin He. 2018. "Does Foreign Direct Investment Enhance Or Inhibit Regional Innovation Efficiency?" *Chinese Management Studies* 12 (1): 35-55. https://doi.org/10.1108/cms-02-2017-0034.

Liu, Feng-chao, Denis Fred Simon, Yu-tao Sun and Cong Cao. 2011. "China's Innovation Policies: Evolution, Institutional Structure, and Trajectory." *Research Policy* 40 (7): 917-931. https://doi.org/10.1016/j.respol.2011.05.005.

Liu, Xielin, Sylvia Schwaag Serger, Ulrike Tagscherer and Amber Y. Chang. 2017. "Beyond Catch-Up—can a New Innovation Policy Help China Overcome the Middle Income Trap?" *Science and Public Policy* 44 (5): 656-669. https://doi.org/10.1093/scipol/scw092.

Lundvall, Bengt-Åke. 1998. "Why Study National Systems and National Styles of Innovation?" *Technology Analysis & Strategic Management* 10 (4): 403-422. https://doi.org/10.1080/09537329808524324.

Luo, Yadong and Rosalie L. Tung. 2007. "International Expansion of Emerging Market Enterprises: A Springboard Perspective." *Journal of International Business Studies* 38 (4): 481-498. https://doi.org/10.1057/palgrave.jibs.8400275.

Mah, Jai S. 2007. "Industrial Policy and Economic Development: Korea's Experience." *Journal of Economic Issues* 41 (1): 77-92. https://doi.org/10.1080/00213624.2007.11506996.

Mathews, John A. and Dong-Sung Cho. 2000. *Tiger Technology: The Creation of a Semiconductor Industry in East Asia* Cambridge University Press. https://doi.org/10.1017/CBO9780511552229.

Moreira, Mauricio Mesquita. 1995. *Industrialization, Trade and Market Failures: The Role of Government Intervention in Brazil and South Korea* Springer. https://doi.org/10.1007/978-1-349-23698-5.

Mu, Qing and Keun Lee. 2005. "Knowledge Diffusion, Market Segmentation and Technological Catch-Up: The Case of the Telecommunication Industry in China." *Research Policy* 34 (6): 759-783. https://doi.org/10.1016/j.respol.2005.02.007.

Mytelka, Lynn K. 2006. "Pathways and Policies to (Bio) Pharmaceutical Innovation Systems in Developing Countries." *Industry and Innovation* 13 (4): 415-435. https://doi.org/10.1080/13662710601032770.

Nelson, Richard R. 2008. "Economic Development from the Perspective of Evolutionary Economic Theory." *Oxford Development Studies* 36 (1): 9-21. https://doi.org/10.1080/13600810701848037.

Öniș, Ziya. 1991. "The Logic of the Developmental State." *Comparative Politics* 24 (1): 109-126. https://doi.org/10.2307/422204.

Paul, Justin and Gabriel R. G. Benito. 2018. "A Review of Research on Outward Foreign Direct Investment from Emerging Countries, Including China: What do we Know, how do we Know and Where should we be Heading?" *Asia Pacific Business Review* 24 (1): 90-115. https://doi.org/10.1080/13602381.2017.1357316.

Porter, Michael. 1990. *The Competitive Advantage of Nations*. New York: The Free Press.

Rosenkopf, Lori and Paul Almeida. 2003. "Overcoming Local Search through Alliances and Mobility." *Management Science* 49 (6): 751-766. https://doi.org/10.1287/mnsc.49.6.751.16026 .

Rutkowski, Aleksander. 2006. "Inward FDI, concentration, and profitability in the CEECs: Were the domestic firms crowded out or strengthened?" Transnational Corporations 15 (3): 105-139. https://unctad.org/en/Docs/iteiit20063a4_en.pdf.

Sakakibara, Mariko and Dong-Sung Cho. 2002. "Cooperative R&D in Japan and Korea: A Comparison of Industrial Policy." *Research Policy* 31 (5): 673-692. https://doi.org/10.1016/s0048-7333(01)00150-0 .

Saxenian, AnnaLee. 2006. *International Mobility of Engineers and the Rise of Entrepreneurship in the Periphery*. No. 2006/142. WIDER Research Paper. The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki

The World Bank. 2020. *School enrollment, tertiary (% gross)* [Data File]. Retrieved from https://data.worldbank.org/indicator/se.ter.enrr

Xie, Wei and Guisheng Wu. 2003. "Differences between Learning Processes in Small Tigers and Large Dragons: Learning Processes of Two Color TV (CTV) Firms within China." *Research Policy* 32 (8): 1463-1479. https://doi.org/10.1016/S0048-7333(02)00140-3.

United Nations Conference on Trade and Development (UNCTAD). 2015. *Investment policy framework for sustainable development*. United Nations, Geneva.

United Nations Conference on Trade and Development (UNCTAD). 2018. *World Investment Report 2018: Investment and New Industrial Policies.* United Nations, Geneva.

Wei, Yingqi and Xiaming Liu. 2006. "Productivity spillovers from R&D, exports and FDI in China's manufacturing sector." *Journal of International Business Studies* 37 (4): 544-557. https://doi.org/10.1057/palgrave.jibs.8400209.

Zhao, Zhongxiu, Xiaoling Huang, Dongya Ye and Paul Gentle. 2007. "China's Industrial Policy in Relation to Electronics Manufacturing." *China & World Economy* 15 (3): 33-51. https://doi.org/10.1111/j.1749-124X.2007.00067.x.

Appendix

Table A. International collaboration on patenting (1975–2017)

		Electronic		Chemical		Pharmaceutical		Machinery		Transport	
		# of patents	% of int. col.	# of patents	% of int. col.	# of patents	% of int. col.	# of patents	% of int. col.	# of patents	% of int. col.
South Korea	1975–1984	335	0.50	170	1.10	109	4.50	271	1.10	18	0
	1985–1994	30,174	0.30	4,130	0.70	1,535	3.10	11,108	0.40	1,909	0.50
	1995–2004	218,788	0.60	16,989	0.90	6,032	4.40	71,352	0.50	30,119	0.10
	2005–2014	411,872	1.60	44,395	1.60	12,444	4.60	142,311	0.70	54,652	0.20
	2015–2017	74,557	1.80	12,259	1.30	3,068	2.50	31,887	0.80	12,112	0.40
	Total	**735,726**	**1.30**	**77,943**	**1.40**	**23,188**	**4.10**	**256,930**	**0.60**	**98,810**	**0.20**
China	1975–1984	9	4.44	17	17.60	2	100	6	0	0	0
	1985–1994	1,677	8.40	2,439	6.80	607	15.5	1,628	6.0	186	4.80
	1995–2004	48,899	9.80	13,994	6.20	13,030	8.50	13,672	5.30	992	3.80
	2005–2014	166,967	20.10	24,185	18.70	18,970	25.40	38,193	12.20	3,821	9.00
	2015–2017	32,074	22.20	1,895	51.30	1,733	50.00	5,059	19.10	761	19.80
	Total	**249,626**	**18.20**	**42,530**	**15.40**	**34,342**	**20.00**	**58,558**	**11.00**	**5,760**	**9.40**

Table B. Composition of country of collaborating inventors (South Korea) (1975–2017)

Electronic		Chemical		Pharmaceutical		Machinery		Transportation	
South Korea	726,056 (98.69%)	South Korea	76,830 (98.57%)	South Korea	22,216 (95.81%)	South Korea	255,141 (99.30%)	South Korea	98,553 (99.74%)
USA	3,528 (0.48%)	Japan	341 (0.44%)	USA	470 (2.03%)	Japan	576 (0.22%)	Japan	60 (0.06%)
Japan	1,633 (0.22%)	USA	322 (0.41%)	China	102 (0.44%)	USA	528 (0.21%)	Germany	54 (0.05%)
China	1,089 (0.15%)	China	102 (0.13%)	Japan	100 (0.43%)	China	152 (0.06%)	USA	51 (0.05%)
India	608 (0.08%)	Germany	78 (0.11%)	Germany	67 (0.30%)	Russia	96 (0.04%)	India	15 (0.02%)

Table C. Composition of country of collaborating inventors (China) (1975–2017)

Electronic		Chemical		Pharmaceutical		Machinery		Transportation	
China	521,408 (83.52%)	China	107,972 (83.75%)	China	76,847 (68.04%)	China	130,914 (89.41%)	China	13,322 (90.99%)
USA	44,724 (7.16%)	USA	9,910 (7.69%)	USA	23,704 (20.99%)	USA	6,704 (4.58%)	USA	508 (3.47%)
Taiwan	19,602 (3.14%)	Germany	3,378 (2.62%)	Germany	1,726 (1.53%)	Taiwan	3,037 (2.07%)	Germany	253 (1.73%)
South Korea	8,985 (1.44%)	Japan	1,836 (1.42%)	Canada	1,465 (1.30%)	Japan	1,548 (1.06%)	Japan	115 (0.79%)
Japan	5,228 (0.84%)	South Korea	1,184 (0.92%)	UK	1,434 (1.27%)	Germany	824 (0.56%)	South Korea	85 (0.58%)