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Brake Segment for Agglomeration Policy: Engineers as Human Capital

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Abstract: A "segment" is a component of the organization of an agglomeration. The organization of agglomeration is formed by the construction of segments. Manufacturing agglomeration segments can be divided into four main categories: human resources including engineers, physical infrastructure, institutions, and living environment. Each segment then has a specific function in the process of building industrial agglomeration. We focus on the process of building segments in agglomeration formation. We define a "brake segment" as a segment that has a "function" to decelerate the speed of the process. The purpose of this paper is to identify the existence of this brake segment in the process of constructing the segments of the manufacturing agglomeration. We obtained the following three results. First, a modified version of the spatial economic model yields that the number of agglomerated firms is inversely related to the wages of skilled workers. Second, a factor analysis of the data on investment environment costs indicates that in the case of the manufacturing industry, the number of agglomerated firms are inversely related to the wages of engineers. Third, the factor analysis of the six countries in the JBIC survey reveals that the segment that poses the investment issue in foreign direct investment in India is engineers as human capital. We conclude that engineers as human capital are a brake segment. The implication is that the sustained development of "engineers" as human capital is essential for the success of manufacturing industry agglomeration.

Keywords: brake segment; function; engineers; human capital; spatial economics

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1. Introduction

Special economic zones (SEZs) are strongly positive in attracting foreign direct investment (FDI) in China, according to UNCTAD (2019). The notion of industrial hubs by Oqubay and Lin (2020) is a generic term for agglomerations of economic activity that have developed since the Industrial Revolution. Special economic zones (SEZs), industrial parks, and export processing zones (EPZs) have been widely used to catch up and transform the economies of newly industrializing economies in East Asia. However, Zheng and Aggarwal (2020) found that India could not match the scale and success of China's SEZs.

The literature on industrial hubs has focused on different types of industrial hubs: industrial districts, EPZs and SEZs, and small industrial clusters, according to Oqubay (2020) as follows. First, FIAS World Bank's occasional paper by FIAS (2008) views SEZs as 'a tool to enhance industry competitiveness' and defines 'a geographically delimited area, offering certain incentives to businesses which physically locate in the zones' (Farole and Akinci (2011); Zeng (2010)). Second, New Structural Economics by Lin (2012), focuses on a developing country strategy oriented to a latent comparative advantage.

The construction of an agglomeration is not instantly completed, but a sequential process of building the segments. It took more than ten years to construct the manufacturing agglomerations. Third, Kanai and Ishida (2000) called research on the dynamic process of agglomeration building as 'process analysis'. Kuchiki and Tsuji (2011) and Fujita and Kuchiki (2006) use a flowchart approach to industrial agglomeration. The flowchart

approach analyzes the process of constructing agglomeration segments. The flowchart approach was applied to many cases all over the world, as follows: the Malaysian electronics industry by Meyanathan (2011), the Wuhan Optical Valley industry in China by Hu and Liu (2011), the automobile industry in China by He (2011), the Rio de Janeiro Software industry by Botelho et al. (2010), the Austin Technopolis in the US (2008), the Industrial Cluster Plan promoted by the Ministry of Economy, Trade and Industry Japan. Macasaquit (2008) applied it to industrial agglomeration in the Philippines, and Mitra and Mehta (2011) applied this approach to industrial agglomeration in India. They analyze the process of constructing agglomeration segments.

In economic theory, Krugman (1991) built the prototype model to examine where economic activity occurs and why. Fujita et al. (1999) extended the prototype model to establish spatial economics. Using a Hotelling-type framework in central place theory, Henkel et al. (2000) obtained the breaking conditions of agglomeration equilibria on spatial allocation decisions in which consumers are active in a marketplace. Helpman and Krugman (1985) provided a new trade theory in spatial economics, in which the equilibrium number of firms is derived based on a general equilibrium model.

By analyzing data on industrial hubs based on a model of spatial economics, the following three conclusions were drawn. First, Kuchiki (2021) used the model of Henkel et al. (2000) to derive the segment that is the master switch in the construction of tourism industrial agglomeration. It is the introduction of both infrastructure that reduces transport costs and heterogeneous goods with low elasticity of substitution.

Second, Kuchiki and Sakai (2023) used the hybrid model of Krugman (1991) and Alonso (1964) to derive the segment that is the master switch of urban agglomeration. It is the introduction of both infrastructure that reduces commuter costs and heterogeneous goods with low elasticity of substitution. Third, Kuchiki (2023) used Helpman and Krugman's (1985) model to derive the segment that is the "accelerator" in the construction of manufacturing agglomerations. It is the "leased" industrial park.

The "segments" constitute the organization of industrial agglomeration. The organization of agglomerations is formed by building segments. The segments comprise four major categories: human resources, physical infrastructure, institutions, and living conditions, according to Kuchiki (2023). Table 1 illustrates some of the investment survey items for the manufacturing industry. The major category of human resources consists of segments: general workers, general office staff, engineers, and section chief staff, or managers.

Each segment has a "function". Its function includes the role of a master switch or accelerator. Ports and roads have the function of master switches for industrial agglomeration policy. Industrial parks have the function of accelerators. We focus on the process of building segments in agglomeration formation.

This paper understands the transition process as a process of constructing segments of an agglomeration and clarifies the importance of the "process of policy implementation". The "sequencing economics" of the construction of segments is then addressed. This paper discusses segments that function to decelerate the process of building segments toward industrial agglomeration. This paper defines the segment as the "brake segment". India has not succeeded in establishing export-oriented SEZs through the introduction of foreign direct investment. Therefore, it is conjectured that some segments function to bake the process of establishing industrial agglomeration. No study has taken up a case study to examine whether brake segments exist and what they are from the viewpoint of theoretical and quantitative analysis when constructing segments of manufacturing agglomerations.

The purpose of this paper is to identify the existence of this brake segment. We will compare India with countries in East Asia, including Vietnam and Thailand, for the purpose of examining in this hypothesis. India did not succeed in introducing export-oriented foreign capital and switched to foreign capital for the domestic market, while Vietnam and Thailand succeeded in introducing foreign capital.

Table 1. Segments and investment-related costs.

Category Segment	Segments	Function	
Human resoruce	worker (general laborer)		W1
	engineer	Brake	W2
	middle management (section chief)		W3
	staff (general office work)		W4
	manager (section chief)		W5
Physical infrastructure	Industrial zone	Accel	Z1
	Industrial zone	Accel	Z2
	Offices		Z3
	Electricity		P1
	Water		P2
	Gas		P3
	Ports	Master switch	C1
		Master switch	C2
	Road	Master switch	
	Airport	Master switch	
Institutions	Deregulation	Master switch	
	Preferential treatments	Master switch	
	One-stop services	Master switch	
	Laws and regulations		
Living conditions	Housing		
	International schools		
	Hospitals		
	Entertainment & shopping		

Source: Author's based on Japan External Trade Organization (JETRO 2022).

The results of this paper were derived in the following three steps. First, a modified version of the spatial economic model yields that the number of agglomerated firms is inversely related to the wages of skilled workers. Second, a factor analysis of the data on investment environment costs indicates that in the case of the manufacturing industry, skilled workers are engineers. In other words, the number of agglomerated firms are inversely related to the wages of engineers. Third, the factor analysis of the six countries in the JBIC survey reveals that the segment that poses the investment issue in foreign direct investment in India is engineers as human capital. A regression analysis of the factor score data confirms this fact.

This paper concludes that engineers as human capital is a brake segment. The implication is that sustained development of "engineers" as human capital is essential for the success of manufacturing industrial agglomeration. To avoid pedaling the brakes in the transition process to an agglomeration equilibrium, it is necessary to sustainably develop engineers as human capital.

Sequencing economics in architecture theory related to agglomeration is applied to sequencing the segments of an agglomeration in terms of 'economies of sequence'. The concept of 'economies of sequence' is defined as the selection and sequencing of any two segments from among the entire group of segments of an industrial agglomeration toward the efficient building of the agglomeration, according to Kuchiki (2021).

This paper is to link the theory of spatial economics with the practice of sequencing economics. Industrial agglomeration consists of organizations, and organizations consist of segments. Sequencing economics is used to embody the theoretical model of spatial economics into agglomeration policy. The "function" of the segments, which are the building blocks of agglomeration, is clarified. The "design" of agglomeration policy is essential for policy makers to design its construction process.

The flowchart approach has so far arrayed segments in the process of building industrial agglomeration. In this approach, the concept of "economies of sequence" was introduced to introduce the perspective of "efficiency" of segment construction. In order to consider efficiency, the "function" of the segment was identified.

Previously, master switches and accelerators were identified as examples of "functions". In addition to these, this paper identifies the engineers as human capital segment

as a segment of the "brake" function. In sequencing economics, identifying the function of a segment leads to efficient implementation of the agglomeration policy. Therefore, sequencing economics is useful for policy makers to implement agglomeration policies.

Section 2 presents preceding studies on the function of segments such as master switch. Section 3 provides an overview of industrial zones in Vietnam and Thailand and special economic zones in India. In Section 4, we explain the materials and methods. In Section 5, we obtain the brake segment using factor analysis and regression analysis. Section 6 concludes this paper.

2. Literature Review on Sequencing Economics

On one hand, Fujita et al. (1999) established in spatial economics 'the study of where and why economic activity takes place'. The results can be used in sequencing economics as location conditions in economic decision-making. On the other hand, Kuchiki (2023) proposed sequencing economics as an architectural theory of agglomeration. Kuchiki (2023) analyzed special economic zones (SEZs) as agglomerations from the perspective of both spatial economics and sequence economics.

The process of constructing an agglomeration identified by Kuchiki (2023) is as follows. The first step in building agglomerations is to determine where to locate them. Spatial economics determines the conditions for this location. Next, the segments of areas determined are constructed to satisfy those conditions.

The analysis of the construction process addressed by Kuchiki (2023) is in the following way. The organization of industrial agglomeration consists of segments. Each of these segments has a function. Kuchiki and Sakai (2023) identified (1) master switches and (2) accelerators as examples of sequencing economics, respectively. Kuchiki and Sakai (2023) found that the segment that reduces transport costs is the master switch and that the segment that reduces fixed costs is the accelerator. This paper finds out which are (3) the "brake" segments that decelerate the construction process of the agglomeration segment.

Figure 1 illustrates the relationship that the master switch, to efficiently construct the segments that make up the agglomeration in sequencing, is the segment that satisfies the symmetry breaking condition.

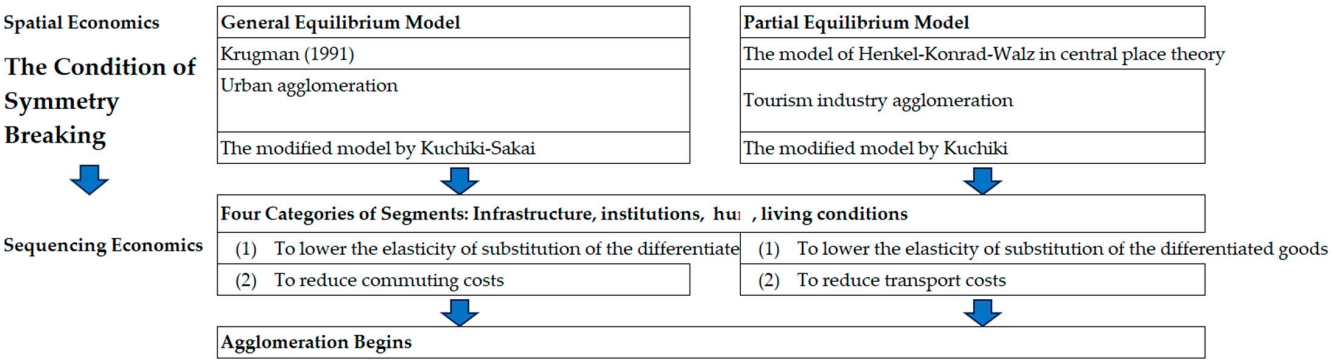

Figure 1. "Master Switch" for agglomeration policy. Source: Author's Illustration.

2.1. The Segments of Master Switch

Kuchiki (2021) used a symmetry breaking condition derived from the Henkel et al. (2000) model in central place theory. This model is a "partial equilibrium" analysis of tourism industrial agglomeration in spatial economics.

Kuchiki (2021) found that in sequencing the tourism agglomeration segments, the master switch was to give first priority to the opening of Universal Studios Japan, which reduces the elasticity of substitution among differentiated goods, and second priority to the construction of Kansai International Airport, which reduces transportation costs. The opening of Universal Studios Japan increased the number of foreign passengers at Kansai International Airport with a two-year lag. Subsequently, the increase in the number of

foreign passengers was lagged by some years, leading to an increase in the number of arrivals and departures at Kansai International Airport, as well as an increase in the number of foreign tourists in Osaka Prefecture.

The economy is a symmetric equilibrium in which manufacturing is equally divided between the two regions as Fujita et al. (1999) defined in Section 5. It found the conditions of the symmetry breaking. Kuchiki and Sakai (2023) used symmetry breaking conditions derived from a "general equilibrium" model in a monocentric city setting as a master switch. Krugman (1991) was used to derive the condition of master switch.

As shown in Figure 2, when a stable symmetric equilibrium is broken, then the construction of segments of an agglomeration equilibrium begins. Kuchiki and Sakai (2023) present the conditions for the master switch to be turned on and identify what segments satisfy those conditions. The condition is that there is a critical value (threshold) for transport costs, and it is necessary to construct segments that reduce transport costs below the critical value. The segments are illustrated as roads, ports, simplification of investment procedures, etc.

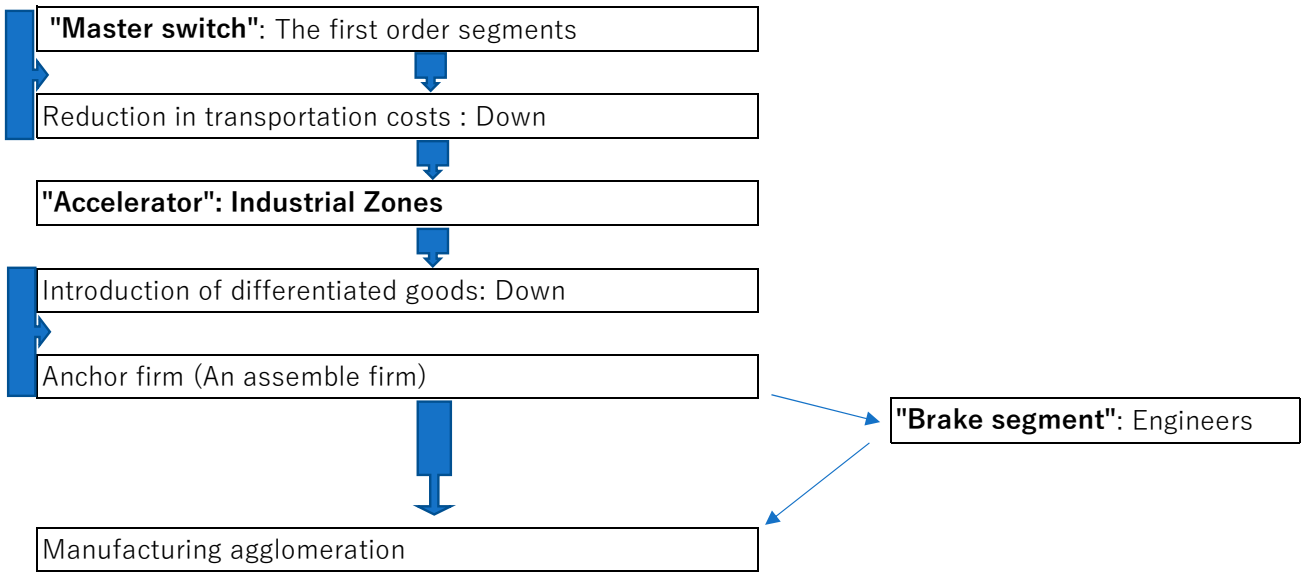

Figure 2. Manufacturing agglomeration policy. Source: Author's illustration.

2.2. The Segments of Accelerator

Figure 2 shows the flow from the master switch through the accelerator to the anchor firm. The conditions for the accelerator segment were derived from Helpman and Krugman's (1985) model of spatial economics. According to the new trade theory of spatial economics, the number of firms in an agglomeration is inversely related to its fixed costs. The main accelerator segment of agglomeration after the master switch is turned on is the formation of segments that reduce firms' fixed costs.

Kuchiki (2023) identifies the accelerator required for the process of agglomeration formation. In the case of manufacturing agglomeration formation, the accelerator segment is specifically industrial parks. The function of this segment is to speed up the process of building the segments of the manufacturing industry agglomeration.

2.3. Brake Segment

Segments that function to decelerate the process of building segments for industrial agglomeration are defined as "brake segments". In the following, we identify the segments that serve as brakes in the segment building process. We then empirically confirm that engineers as human capital is a brake segment.

3. Industrial Agglomerations in Vietnam, Thailand, and India

India has not succeeded in manufacturing agglomeration and is implementing agglomeration policies through the Make in India policy. Many east-Asian countries, including China, have succeeded in establishing manufacturing agglomerations.

In 1981, China and India had approximately the same GDP per capita: USD 275 for India and USD 288 for India; in 2023, India's GDP per capita is USD 2612 and China's is USD 12,541[1]. One can presumably attribute this difference in part to the success of the Special Economic Zone (SEZ) policy that was launched in China in 1979, based on a chronological and statistical analysis by Kuchiki (2023).

Zheng and Aggarwal (2020) conclude that India has failed to match the size and success of China's SEZs in attracting FDI. Ahluwalia et al. (2018) found that India lost its comparative advantage in labor-intensive production in the early stages of development despite its relative abundance of unskilled labor. With regard to the use of SEZs to establish industrial agglomeration, there are differences in the effectiveness of SEZs in India and China.

Two Asian countries that have typically succeeded in using the sequencing economics of agglomeration are Vietnam and Thailand. These countries have been successful in manufacturing agglomeration through the use of ODA as well as the introduction of foreign capital. Sequencing has been optimal in the construction of master switches and acceleration segments.

In the case of these countries, the sequence of ODA implementation along with FDI was optimal. NESDB (2016) of the Thai government identified the results of the Eastern Seaboard Development Program agglomeration with Japanese ODA. Lecler (2002) described the automobile industrial agglomeration in the Eastern Seaboard Development Program, while Shimomura (2000) presented the Japanese contribution to the program and a third-party evaluation. Watanabe (2004) concluded that the combination of FDI and ODA was effective in promoting automobile accumulation in Thailand. The automobile agglomeration is called "Detroit in East Asia".

Similarly, Tran et al. (2003) positively evaluated the impact of Japanese ODA and FDI on industrial agglomeration in northern Vietnam. FDI was in the industrial agglomeration in the north of the country. Mitsui (2004) evaluated that the construction of National Highway 5 with ODA was effective for the agglomeration of FDI. ODA provided the master switch and accelerator through optimal sequencing.

This section presents the segment sequencing. The section highlights successful cases of the introduction of export-oriented foreign direct investment in Vietnam and Thailand, in contrast to unsuccessful cases in India. The process of building master switches and accelerator segments in the process of building industrial agglomeration in Vietnam and Thailand will be illustrated. In this context, the process of developing engineers as human capital with a control function in the Vietnamese process will be highlighted. For the SEZs in India, we will focus on the process of shifting from export-oriented to domestic market-oriented foreign investment without much success in introducing foreign capital.

The cases of Vietnam and Thailand in Kuchiki (2007) are reviewed in these subsections (1) and (2), as shown in Figures 3 and 4. The segments of industrial agglomeration have a master switch and an accelerator pedal as functions. These cases are reinterpreted with respect to the function of the segments.

In this section, on the one hand, Vietnam and Thailand implemented the policy of fostering engineers as human capital. On the other hand, India has implemented agglomeration policies using Special Economic Zones, but has not sufficiently trained engineers as human capital as a segment that constitutes the investment environment in its agglomeration policies.

In the next section, we will theoretically demonstrate that agglomeration does not progress when there is a lack of engineers as human capital based on a model of spatial economics. Thus, we theoretically confirm that the failure of India's manufacturing agglomeration was due to the lack of engineers as human capital.

(Unit: million $)

	Year	ODA
(1) Highway Route 5	**1993, 1995**	**210**
(1) Haiphong Port	**1995, 1999**	**173**
(2) Thanglong Industrial Park	**1997**	
(2) Nomura Haiphong Industrial Zone	**1997**	
(1) Institutional Reform	**1999**	**200**
(3) Canon	**2001**	**Total amount**
		583
100 suppliers	**2008**	
30 thousand employees		

Figure 3. The electronics industry agglomeration in northern Vietnam. Source: Tran et al. (2003) based on JBIC-IDCJ (2003). Note: ODA is official development assistance.

	Loan contract agreement	Loan completion	Loan executed	executed
Water/Aqueduct Project	7/1982	4/1987	36.06	36.06
(1) Leamchabang Port	9/1984	6/1993	31.78	
	11/1986	11/1993	48.42	
	2/1990	9/1995	58.68	
	10/1985	10/1992	25.76	
	9/1987	9/1992	19.89	184.53
(2) Leamchabang Industrial Estate	10/1985	10/1992	25.76	
	9/1987	9/1992	19.89	45.65
Railway Projects				
Siracha/Leamchabang	9/1988	7/1996	9.2	
Sattahip/Maptaphut	9/1988	1/1997	28.26	
Khlong19/Kengkoi	2/1990	12/1999	72.98	110.44
Road Projects				
Chonburi/Pattaya	11/1988	3/1994	40.74	
Bangkok/Chonburi	12/1990	4/1993	134.35	
Outer Bangkok Ring	12/1990	4/1993	128.28	303.37
				680.05
(3) Mitsubishi Motors	Established in 1990			

Figure 4. Eastern Seaboard. Source: Kuchiki and Tsuji (2011) based on Shimomura (2000).

3.1. Agglomerations in Northern Vietnam

This subsection identifies the role of the "master switch" and accelerator in the establishment of industrial agglomeration through Japanese official development assistance in the case of industrial agglomeration in northern Vietnam[2].

3.1.1. Roads and Ports: Reduction of Transport Costs as Master Switch

The construction and renovation of National Highway No. 5 and Haiphong Port were effective as master switches for the building of industrial agglomeration. Figure 3 shows that JPY (Japanese Yen) 21 billion was provided for the construction of National Highway 5 and JPY 17.3 billion for the renovation of Haiphong port in 1993 and 1995.

3.1.2. Institutions: Reduction of Transport Costs as Master Switch

In April 1999, Japanese Minister of Finance Miyazawa pledged JPY 20 billion to support a private sector development program. The loan was agreed upon and implemented in September 1999.

According to the JBIC-IDCJ survey (2003), as shown in Table 2 and Figure 5, private companies evaluate the effect of institutional change on transportation cost reduction from four main perspectives[3]. First, the approval system for new business was abolished and changed to a registration system. Second, sub-licences are abolished. Changes in company formation streamlined administrative procedures. Third, the collateral and access to banks are improved. Lastly, trade was liberalized. The number of restricted or prohibited industries decreased from 400 to 250.

Table 2. Benefit of Well-developed Infrastructure.

Type	Production	Market-Local	Market-Export	Import	Hai Phong Port	Highway No. 5	Example
1	Hanoi		Haiphong	Haiphong	B	B	Canon
2	Hanoi	Local	Haiphong	Haiphong	B	B	TOTO
3	Hanoi	Local		Haiphong	B	C	Vietnam Float Glass
4	Hanoi		Via internet	CAD technology			Yabashi
5	Hanoi		Noi Bai	Haiphong	C	C	Sumitomo Bakelite
6	Haiphong		Haiphong	Haiphong	B		As'ty
7	Haiphong	Local		Haiphong	B	C	San Miguel Yamamura
8	Haiphong	Local	Haiphong	Haiphong	A (inc.local distribution by ship)	B	Han-Viet Heavy Industry & Construction
9	Haiphong		Noibai	Noibai		B	ESTELL
10	Vinh Phuc	Local		Haiphong	C	C	Honda

Note: A, B and C show frequency of use. A: extremely frequent, B: very frequent, C: frequent. Source: Kuchiki (2007) based on JBIC-IDCJ (2003).

3.1.3. Thang Long Industrial Park and Nomura Haiphong Industrial Zone as Accelerator

Both Thang Long Industrial Park (TLIP) and Nomura Haiphong Industrial Zone (NHIZ) served as accelerators to help investors reduce their initial fixed costs. The development area is 121 hectares for TLIP and 180 hectares for NHIZ.

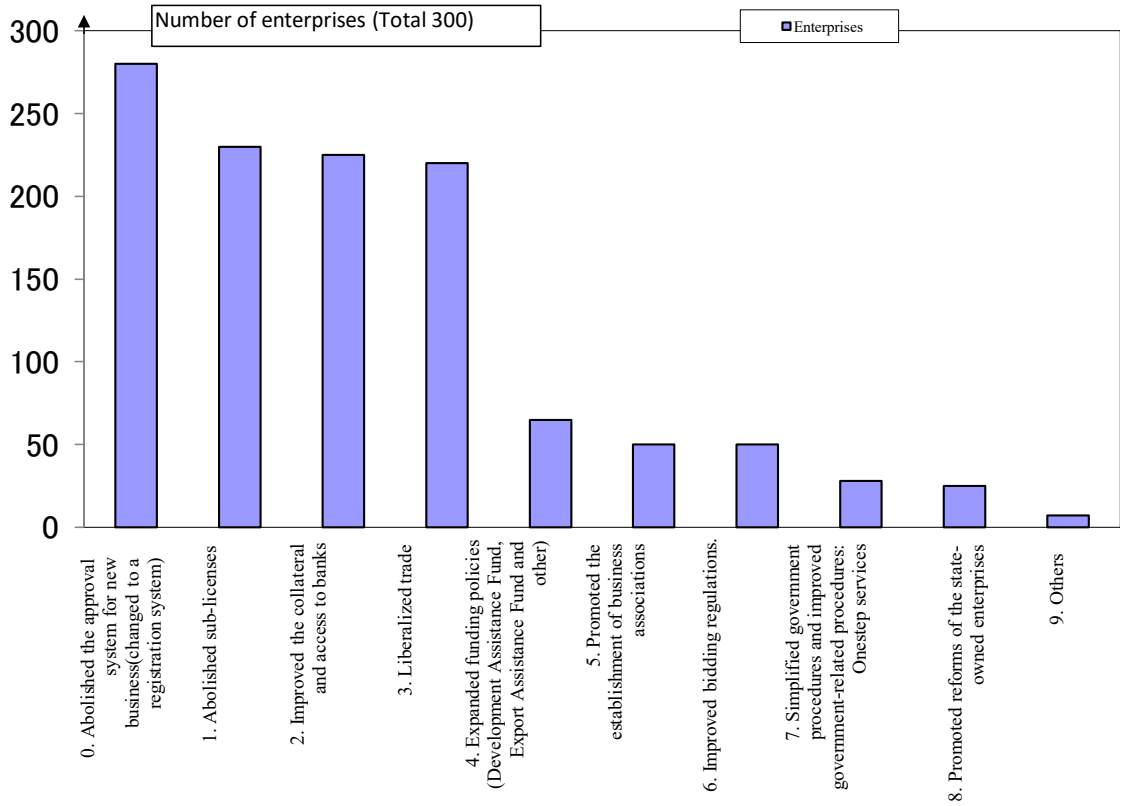

Figure 5. Institutional reforms Note: Data collected from private companies only. Source: Kuchiki (2007) based on JBIC-IDCJ (2003).

3.1.4. Engineers as Human Capital

Many projects developed engineers as human capital to keep the manufacturing agglomeration process from decelerating. One project at Hanoi Institute of Technology taught skills in machining, metalworking, and electrical control. The Haiphong High-Tech Skill Training School was established in December 2001. Major subjects included information and graphics, electrical and electronic engineering, polymers, welding, and milling. Students from both schools first graduated in 2003.

3.1.5. Industrial Agglomerations in Northern Vietnam

Based on the data on foreign direct investment growth from 2000, before the completion of the electronics industry agglomeration, to 2004, after its completion, the macroeconomic effects of National Highway No. 5 on the economy of northern Vietnam are shown in Table 3.

Table 3. Change in direct investment (registerd amount) and number of investments by region. (lower: number of investments; higher: US$ millions).

	2000	**2001**	**2002**	**2003**	**2004**	**2004/2000**
North	62.3	272.9	375.4	604.5	1195.9	19.2
Central	58.7 (18)	128 (35)	145.1 (39)	218.4 (59)	405.2 (39)	6.9 2.2
South	707.1 (284)	2102.2 (378)	992.1 (536)	1061.1 (484)	2609.6 (486)	3.7 1.7

Source: Kuchiki (2007).

The data are shown in Table 3 for Hanoi and Haiphong in northern Vietnam, Danang in central Vietnam, and Ho Chi Minh City in southern Vietnam. In 2004, the growth rate in

the north was higher at 19.2%, while the growth rates in the central and southern regions were lower at 6.9% and 3.7%, respectively.

3.2. The Case of Eastern Seaboard Region in Thailand

This subsection identifies the role of the "master switch" and accelerator in the establishment of industrial agglomeration through Japanese Official Development Assistance in the case of the Eastern Seaboard Region in Thailand.

The objective of the Eastern Seaboard Development Program was to establish industrial agglomeration in Laem Chabang as a location for export-oriented industries and general industrial estates[4]. The Laem Chabang program included the construction of port facilities and the Laem Chabang Industrial Estate, with associated infrastructure improvements related to water supply, communications, railroads, roads, and urban development[5].

The Japan Bank for International Cooperation (JBIC, formerly the Overseas Economic Cooperation Fund) provided 27 loans for 16 projects under the Eastern Seaboard Development Program; over an 11-year period from 1982 to 1993, at a total cost of approximately USD 680 million, the process of automobile industrial agglomeration shown in Figure 5 was completed[6].

The "Laem Chabang Regional Development Plan" consisted primarily of the development of Laem Chabang Port and the construction of Laem Chabang Industrial Park. Loan agreements for the water supply project and the "Laem Chabang Port" project were agreed in 1982 and 1984, respectively. The loan agreement for the Laem Chabang water pipeline project was agreed in 1984. The loan agreement for the Laem Chabang Industrial Park was signed in 1985. The loan agreement for the railroad and road project was agreed upon in 1988.

3.2.1. Master Switch

Laem Chabang Port was designed as a new deep-water port to replace Bangkok Port. The port plays an important role in Laem Chabang Industrial Estate's function as an export processing zone.

3.2.2. Accelerator Segment

As of 1999, Laem Chabang Industrial Park covers an area of 420 ha. Total loans amounted to JPY 2.576 billion since 1985 and JPY 1.989 billion since 1987. Mitsubishi Motors began operations at Laem Chabang Industrial Park in 1992 as an assembly anchor company. The industrial park functioned as an accelerator segment of the automotive industrial agglomeration by reducing the fixed costs of moving in component suppliers.

3.2.3. Engineers as Human Capital

The Council of Engineers Thailand (COET) is a statutory body under the Engineer Act, B.E. 2542 (1999). The professional engineering services in Thailand are regulated and controlled under the Act which is the central regulatory body for engineering services in Thailand. Policies promoting STEM (Science, Technology, Engineering, and Mathematics) education were introduced in 2014 (ASEAN NOW 2014).

3.2.4. Agglomeration

The peak period for the establishment of industrial parks in the Eastern Seaboard provinces of Chonburi, Prachinburi, Chachoengsao, and Rayong was from 1985 to 1995. These provinces established industrial parks for Toyota in the Gateway City Industrial Park, GM in the Eastern Seaboard Industrial Park, and BMW in the Amata City Industrial Park (see JETRO (2009))[7]. Along Route 331 in the Eastern Seaboard region, the Thailand automobile industry agglomeration was developed.

3.3. The Indian SEZ Policy

3.3.1. EPZ (Export Processing Zone) (1965)

The Indian Government used Export Processing Zones (EPZs) to promote exports. The first EPZ in Asia was established in Kandla, Gujarat as well as Kaohsiung, Taiwan in 1965. The success of Kaohsiung is well known[8].

3.3.2. SEZ Policy 2000

Though the EPZs had a similar structure to SEZs, the Government initiated the establishment of SEZs, which differ from the EPZs, under the Foreign Trade Policy in 2000. The SEZ Policy 2000 set up under the EPZ regime aimed to address issues arising from numerous regulatory controls, inadequate infrastructure, and unreliable fiscal regimes, and to attract higher foreign direct investment into India from international and multinational companies. This was modeled after China's Special Economic Zones, according to Aggarwal (2006).

However, Zheng and Aggarwal (2020) found that the SEZ Policy 2000 under the EPZ regime made a limited contribution to the Indian economy and that in 2003–2004, all seven EPZs created a mere 8.94 kilo square meter and 88,700 workers at 1 per cent of formal manufacturing employment. The share of FDI in total EPZ investment was as low as 25 per cent in 2003.

3.3.3. SEZ Act 2005 and SEZ Rules 2006

In 2005, the EPZs were converted into the Special Economic Zones Act 2005 (SEZ) to address the infrastructure and bureaucratic issues they faced. The Act was amended to make the SEZ policy with the goal of making India a global manufacturing powerhouse.

The SEZ Rules 2006 set out a complete procedure for the development of SEZs or the establishment of establishments in SEZs. As a result, the SEZ category includes various multiple types of zones, such as free trade zones, EPZs, industrial estates (IEs), free ports, free trade warehousing zones, and urban enterprise zones. A number of EPZs were converted into SEZs, including Noida (Uttar Pradesh), Chennai (Tamil Nadu), Santacruz (Maharashtra), and Kandla (Gujarat). The SEZ Act amended India's SEZ policy.

However, the SEZ Act 2005, which aimed to transform the country into a global manufacturing powerhouse, had a very limited effect. India adopted a cautious approach to SEZ policy and the SEZ Act 2005 gave way to pessimism and foreign investors largely stayed away. The 262 SEZs established during the period from 2005 to 2022 had only 5576 units in operation and accounted for less than 20% of exports[9].

3.3.4. Development Enterprises and Services Hub (DESH) Bill 2022

The Special Economic Zone Policy 2005 was replaced by a new law in the 2022 budget. The Development Enterprises and Services Hub (DESH) Bill aims to establish development hubs. Its objectives are to maintain the competitiveness of "manufacturing" and exports, promote economic activity, create jobs, integrate with global supply and value chains, develop infrastructure facilities, and promote investment, including research and development.

The bill is expected to shift the focus from exports to domestic investment and lead to a paradigm shift by integrating several SEZ models, including Special Economic Zones, Coastal SEZs, and Food and Textile Parks[10]. The purpose of the bill is to go beyond an export-oriented approach and establish "manufacturing clusters through foreign direct investment for domestic production in India".

As of 2024, some incentives for setting up procurement and manufacturing platforms within India's SEZs include duty-free import and domestic procurement of goods, 100% income tax exemption on export income from SEZ units for the first five years, 50% for five years thereafter, and 50% of export profits ploughed in for the next five years[11].

As of September 2022, the Indian state of Tamil Nadu had the highest number of operational Special Economic Zones (SEZs), followed by Maharashtra and Telangana. As of

2023, India has 272 SEZs, employing a combined 2.8 million people[12]. These SEZs generate approximately USD 133 billion in exports, with services exports, rather than manufacturing exports, accounting for about 60% of these exports.

3.3.5. Issues in the Segment of the Investment Environment

The Government of India has initiated several steps to improve the investment attractiveness of SEZs and has constituted the Baba Kalyani Committee to recommend changes in India's SEZ policy based on inputs from various stakeholders[13]. Investment attractiveness, or the investment environment, depends on which segments of the agglomeration are well-developed.

This paper examines the shortfalls of segments in India in terms of foreign direct investment compared to China and other Asian countries and identifies the factors that contribute to this shortfall. The conclusion is that the shortage of engineers is the cause of the brake on the building of manufacturing industrial agglomeration.

4. Methods and Materials

4.1. The Model of Helpman and Krugman on Human Capital

The analysis is discussed in the following three steps. In this section, we obtained the hypothesis that the number of manufacturing agglomerations is inversely proportional to the present value of the lifetime wages of the "skilled labor force as human capital", which constitutes fixed capital, through a modified model of spatial economics. In other words, the number of manufacturing agglomerations is inversely related to the shortage of "skilled labor as human capital".

We follow the original model of Helpman and Krugman (1985) in their new trade theory in spatial economics: "They derived the equilibrium number of firms based on a general equilibrium model; Their model consists of two countries, 1 and 2, where the two sectors are manufacturing and agriculture, the population L_k of country k (=1, 2) is constant; The model assumes that firms produce a variety of differentiated goods in both countries 1 and 2".

We describe the behavior of the consumer. The consumer's expenditure minimization problem is solved. There are two types of consumption goods: agricultural consumption, which is homogeneous goods, and differentiated goods consumption. Agricultural consumption for unskilled workers in country k is denoted as A_k. Differentiated goods consumption is denoted by M_k and is a CES type of substitution function defined over a continuous variety of consumption goods.

In the first step, minimizing a representative consumer's expenditure subject to differentiated goods consumption M_k yields the first-order conditions. Notations are as follows: the number of differentiated products, or firms, in country k is given as n_k; p_{sk} (i) is the price of the goods i produced in country s and consumed in country k; $m_{sk}$is the consumption of goods producted in country s and consumed in country k; and the parameter σ is the elasticity of substitution between any two of the varieties of goods. Minimizing (2) subject to (1) yields the first-order conditions, where M_k is given as

$$M_k = \left[\sum_{s=1}^{2} \int_0^{n_s} m_{sk}(i)^{\frac{\sigma-1}{\sigma}} \mathrm{di}\right]^{\frac{\sigma}{\sigma-1}}, \text{ for } k = 1,\ 2, \text{ and} \tag{1}$$

a representative consumer's expenditure is

$$\sum_{s=1}^{2} \int_0^{n_s} p_{sk}\ (\mathrm{i})\ m_{sk}\ (i)\ \mathrm{di}. \tag{2}$$

In the second step, the utility maximization problem is solved subject to budget constraints. The utility function of a representative skilled worker in country k is given as

$$U_k = {M_k}^{\mu}\ {A_k}^{1-\mu}, \text{for } k = 1, 2. \tag{3}$$

The budget constraints for representative skilled workers in country 1 and country 2, respectively, are given as

$$yk = \sum_{s=1}^{2} \int_0^{n_s} p_{sk} m_{sk}\,(i)\mathrm{di} + Ak, k = 1, 2. \tag{4}$$

The utility function of a representative skilled worker in country k is a Cobb–Douglas type. Then, Helpman and Krugman (1985) obtained

$$m_{sk}\,(i) = (p_{sk}\,(i)^{-\sigma}/{P_k}^{1-\sigma})\; y_k\; \mu, \text{ for } k = 1, 2, s = 1, 2, \tag{5}$$

where $P_k = [\sum_{s=1}^{2} \int_0^{n_s} p_{sk}(i)^{1-\sigma}\mathrm{di}]^{1/(1-\sigma)}$, for $k = 1, 2$.

Next, firms maximize profit. Each firm produces and also trades one good and incurs a variable cost c and a fixed cost F_k. The profit $\pi_k\,(i)$ of a firm producing variety i in country k and selling in countries k and s is given as

$$\pi_k\,(i) = \pi_{kk}(i) + \pi_{ks}\,(i) - F_k = (p_{kk}\,(i) - c)\; m_{kk}(i)\; L_k + (p_{ks}\,(i) - \tau\, c)\; m_{ks}\,(i)\; L_s - F_k, \quad \text{for } k = 1, 2, s = 1, 2, s \neq k, \tag{6}$$

where L_k is the population number, τ is the "iceberg" transport costs.

The first-order conditions determine the equilibrium prices,

$$p_{kk}\,(i) = p = \sigma c/(\sigma - 1),\; p_{ks}\,(i) = \tau p, \text{ for } k = 1, 2, s = 1, 2, s \neq k, \text{ and} \tag{7}$$

$$P_k = p\,(n_k + n_s\;\varphi)^{1/(1-\sigma)}, \text{ for } k = 1, 2, s = 1, 2, s \neq k, \tag{8}$$

where $\varphi \equiv \tau^{(1-\sigma)}$.

Substituting (5), (7), and (8) in (6) obtains the firm's profits producing variety i in country k:

$$\pi_k\,(i) = (\mu/\sigma)\;[(y_k\; L_k)/(n_k + \varphi\; n_s) + (\varphi\; y_s\; L_s)/(\varphi\; n_k + n_s)] - F_k.$$

for $k = 1, 2, s = 1, 2, s \neq k$.

Here, different from Helpman and Krugman's (1985) fixed costs, this paper assumes that fixed capital consists of human capital (H) and physical capital (F). According to Pflüger (2003), manufacturing engineers, or skilled labor, belong to human capital. Their lifetime wage is assumed to be W_{kE}. In the "manufacturing" sector, engineers and so-called skilled workers are included in the category of skilled labor. Hence, engineers and skilled workers can be assumed to be human capital as a fixed factor of production rather than a variable factor of production.

$$F_k = W_{kE}\; H_{kE} + F_{kP}$$

where W_{kE} are the lifetime wages of skilled labor in country k, H_{kE} are the number of engineers in country k, and F_{ake} are the fixed costs of physical capital in country k.

Thus, the zero-profit conditions obtain

$$n_k = (\mu/\sigma)\;[y_k\; L_k/(F_k - \varphi F_s) + \varphi\; y_s\; L_s/(\varphi\; F_k - F_s)],\; k = 1, 2, s = 1, 2, s \neq k.$$

We derive the following equation:

$$\partial n_k/\partial W_{kE} = -(\mu/\sigma)\; H_{kE}\;[y_k\; L_k/(F_k - \varphi\; F_s)^2 + \varphi^2\; y_s\; L_s/(\varphi\; F_k - F_s)^2] < 0, \text{ and}$$

Thus, the above equation reveals that the number of firm agglomerations is inversely related to the fixed cost F_k. The higher W_{kE} is, the closer the number of firms approaches zero. In other words, $N \to 0$ when the number of skilled labor as human capital is insufficient and

$W_{kE} > {W_{kE}}^{UL}$. We obtain the following result:

Result 1. *The number of manufacturing agglomerations is inversely related to the shortage of "skilled labor as human capital".*

4.2. Materials

Factor analysis extracts the common factors (f) latent behind the observed variables. The observed data are the explained variable (x_i). The common factor is the "communality", or the explanatory variable (f), and the part that cannot be explained by the common factor is the "uniqueness" (u_i), which is the unique factor of (x_i), then $x_i = b_{ij}\, f + u_i$. The coefficient (b_{ij}) of the explanatory variable that is the common factor are the factor "loadings". Using the variance–covariance matrix of x_i, they are obtained by multiplying the square root of the eigenvalues of the factor loading matrix by the eigenvector u.[14]

Factor "scores" are explained in the following. The factor loadings in factor analysis represent the correlations between observed variables (x_i) and the underlying latent factors (f). Each factor loading (b_{ij}) indicates the strength and direction of the relationship between a particular variable and a particular factor. Higher factor loadings indicate a stronger association between the variable (x_i) and the factor (f), suggesting that the variable (x_i) contributes more to the definition of the factor (f).

Factor scores in factor analysis refer to the estimated scores or values of the latent factors (f) for each individual or observation in the data set. These scores are calculated based on the observed variables and the factor loadings obtained from the factor analysis model. The factor score essentially reflects the degree to which each individual exhibits the characteristics associated with the latent factors (f) identified by the factor analysis.

JETRO (2022) examines a segment of investment-related costs, as shown in Table 4 as an example. The costs correspond to the segments of Japanese companies operating in 100 cities and regions in about 60 countries. The original data used are shown in "Table A2. Data for Factor Analysis" in Kuchiki (2023). Table 9 in Kuchiki (2023) is the list of the survey cities used in this paper. The result of the factor analysis is shown in Appendix Table A3 in Kuchiki (2023).

Table 4. Segments and investment-related costs.

	The Environmnet of Investment in the Manufacturing Industry	US$
W1	worker (general labor)(per month)(manufacturing)	469
W2	engineer (intermediate technician) (per month)(same as above)	768
W3	middle management (section chief) (per month)(same)	1677
W4	staff (general office work) (per month)(non-manufacturing)	722
W5	manager (section chief) (per month)(same as above)	1584
Z1	industrial zone (land) (purchase price) (per square meter)	27.8
Z2	industrial zone rent (per square meter, per month)	4.76
Z3	office rent (per squre meter, per month	30.1
P1	commercial electricity rates (pre 1 kWh)	0.54
P2	commercial water rates (per cubic meter)	0.77
P3	commercial gas rates (per 1 kg)	0.64
C1	container transport to Japan (40 ft)	1420
C2	container transport to the third country (40 ft)	12,450

Note: The environment is the case of Mumbai, India. Source: Author's based on Japan External Trade Organization (JETRO 2022).

Table 4 is the list of the investment-related costs consisting of the wages of workers (general labor) (W1), engineers (intermediate technician) (W2), middle management (section chief) (W3), staff (general office work) (W4), and managers (section chief) (W5) in the case of Mumbai, India. Other costs are leased prices of industrial zones (Z2), purchased rents for industrial zones (Z1), commercial electricity rates (P1), and container transportation to Japan (C1). Here, W1, W2, W3, W4, and W5 refer to the monthly wages of the various types of labor.

JBIC (2007–2022) Survey Report on Overseas Business Operations by Japanese Manufacturing Companies from 2007 to 2022 aimed to research and analyze the current status and future prospects for overseas business development of Japanese manufacturing companies. The companies targeted in this survey are Japanese manufacturing companies which have three or more overseas affiliates. This paper uses the data of the details of both issues and promising reasons, and, in particular, focuses on the details of issues. Factor analysis is applied to the top ten countries from 2007 to 2022. The six countries are India, Vietnam, Indonesia, Thailand, the US, and China. For example, regarding (Japan Bank for International Cooperation) (JBIC 2007–2022), the number of surveyed companies is 946, and the number of respondents is 531. This paper provides a factor analysis regarding the reasons for the high potential and the reasons for the issues in investing in the promising investment countries.

China was the first promising country in 2018. Appendix A illustrates the statistics of promising and issue items in Tables A1 and A2, respectively. Among the issue items in Table A2, which are China's challenges, the issue item with the highest number of firms is (o) Intense competition with other companies with 132 firms, and the item with the second-highest number of firms is (m) Rise in labor costs with 129 firms. However, it is noteworthy that the issue items with consistently high loading scores in the factor analysis are institutional reasons such as (h) Insufficient protection of intellectual property rights and (i) Foreign exchange and remittance restrictions.

We use high potential, or promising reasons, which are conditions that promote industrial agglomeration in each country. Appendix B shows the factor loadings as follows: The first factor, ML1, represents 'FDI-led agglomeration': (o) Local logistics services (1.1); (n) Local physical infrastructure (1); (r) Stable political and social conditions (1); (l) Profitability of local market (0.9); and (m) A base for product development (0.7).

The second factor, ML2, represents 'Human resources of low-wage labor': (b) Low-wage labor (0.7); (a) Excellent human resources (0.5); and (f) Risk diversification receptacle for other countries (0.6).

The third factor, ML3, represents 'Export processing zone': (p) Preferential tax incentives for investment (0.9); (q) Stable policies to attract foreign investment (0.9); (h) An export base to Japan (0.8); (g) An export base to third countries (0.6); and (d) A supple base to assemble makers (0.4).

The fourth factor, ML4: 'Raw material procurement': (i) Advantage in procurement of raw materials (0.6); and (c) Cheap parts and raw materials (0.5). Here, the values of parentheses are factor loadings (Kuchiki (2023), pp. 10–11).

This paper focuses on the issues that hinder industrial agglomeration. Regarding the factor loadings of the issues of investment, ML1 of Institutional Issues consists of (h) Insufficient protection of intellectual property rights (1), (i) Foreign exchange and remittance restriction (1), (b) Unclear operation of legal system (0.9), and (p) Difficulty in collecting payments (0.9).

In terms of the operation of the legal system, they are (f) Strengthening of taxation (0.9), (j) Import regulations and customs procedures (0.8), (e) Strengthening taxation (0.8), (g) Investment licensing procedures are complicated and unclear (0.8), (m) Rise in labor costs (0.8), (d) Operation of the tax system is unclear (0.7), (q) Difficulty in raising funds (0.5), and (n) Labour issues' (0.5).

ML 2 of Industrial Agglomeration consist of (r) Underdevelopment of local supporting industries (1.1), (a) Underdeveloped legislation (1), (t) Underdeveloped infrastructure (0.9), (o) Intense competition with other companies (−0.9), (v) Lack of information on investing countries (0.9), and (s) Lack of currency and price stability (0.7).

ML 3 of Human Capital of Engineers and Managers consists of (k) Difficulty in securing local engineers (0.8) and (l) Difficulty in securing management-level personnel (0.8).

ML 4 of Insecurity and Social Instability consists of (u) Insecurity and social instability (0.8) and (c) Complexity of the tax collection system (0.5).

The factors that this paper will pay particular attention to in the next section are ML 3, Engineers and Managers. In particular, engineers as capital stock as a fixed factor of production in the manufacturing industry.

5. Empirical Analysis of Brake Segments

In this section, a factor analysis using JETRO data divided the investment environment segments into three factors: The first factor is workers (general labor) and staff (general office work). The second factor is middle management (section chief) and managers (section chief). The third factor is engineers (intermediate technician) for W2.

Furthermore, a factor analysis was conducted on the investment issues of FDI in the six most promising investment destinations for Japanese firms using JBIC data: the six countries are India, Vietnam, Thailand, Indonesia, China, and the United States. As discussed in Sections 3.3.3 and 3.3.4, among these countries, India has been braking because it is not as agglomerated as other countries in terms of exports. The results of the factor analysis and regression analysis proved the hypothesis that the issue in India's investment environment from 2007 to 2021, or a brake segment, is the "engineers" segment. Hence, we can conclude that the brake segment is engineers as human capital.

A summary of the results obtained by factor analysis reveals that only India has a factor score of more than 1 for having issues with engineers from 2007 to 2021 (not including 2022. For the other countries, the factor score exceeds 1 for Vietnam only for 2007 and 2008, and for Thailand only for 2020. In other words, we can conclude that engineers are the factor that poses a challenge to the establishment of industrial agglomeration in India.

5.1. Factor Analysis of Workers, Engineers, and Managers

Industrial agglomeration is basically formed at the city level. In most countries, the leading cities drive the economic growth of the country at the national level. Kuchiki (2020) in the Oxford Handbook of Industrial Hubs and Economic Kuchiki (2023) showed this fact for China and ASEAN, respectively. Therefore, we will conduct a factor analysis on a city-by-city basis.

As shown in Appendix C, the conclusion obtained in this section is that investment-related costs can be categorized into three factors. The first factor of ML 1 is workers (general labor) in W1 and staff (general office work) in W4. The second factor of ML 2 is middle management (section chief) for W3 managers and managers (section chief) for W5. The third factor of ML 3 is engineers (intermediate technician) for (W2). The definition of engineers (intermediate technician) (W2) does not include so-called skilled workers.

Therefore, the paper supposes that ML 3 of "engineers" belongs to skilled labor as the human capital of fixed costs in the manufacturing industry. Integrating this result with Result 1 yields the following result:

Result 2. *The number of manufacturing agglomerations is inversely related to the shortage of engineers as "human capital".*

5.2. Promising Factors of Investment

As shown in Table 5a, we conclude the characteristics of the factor scores for each country in the following. Vietnam has high scores for Factor 2, ranging from 1.13 to 3.09 between 2007 and 2022, and is promising with respect to inexpensive labor. Thailand has high scores for Factor 3, ranging from 0.5 to 2.44 between 2007 and 2022, and is promising in terms of foreign investment in EPZs, etc. The US has high scores for Factor 1, ranging from 0.97 to 3.18 between 2007 and 2022, and is promising in terms of industrial agglomeration. China has high scores for Factor 4, ranging from 0.77 to 2.15 between 2007 and 2015, and is promising for investment in cheap raw materials and cheap parts.

Table 5. (a) Factor scores of investment promising reasons by year by coutry by factor analysis. (b) Factor scores of investment issues by year by coutry by factor analysis.

(a)

	India				Vietnam				Thailand				Indonesia				China				U.S.			
	Agglo	FDI	Worker	Materi	Agglo	FDI	Worker	Materi	Agglo	FDI	Worker	Materi	Agglo	FDI	Worker	Materi	Agglo	FDI	Worker	Materi	Agglo	FDI	Worker	Materi
2007	−0.77	−0.52	0.96	0.37	-0.32	1.28	3.09	−1.85	0.17	2.08	0.43	0.37	−0.90	−0.57	0.57	2.67	−0.88	0.59	−0.07	2.16	2.76	−1.06	−0.17	−0.61
2008	−0.74	−0.70	0.60	−0.12	−0.58	1.00	2.24	−1.53	0.11	1.63	0.08	−0.13	−0.93	0.66	0.43	1.76	−0.71	0.16	−0.20	2.10	2.05	−1.48	−0.24	−0.99
2009	−0.85	−0.83	0.43	0.27	−0.68	0.67	1.72	−0.69	0.21	2.26	−0.07	0.39	−0.84	0.21	0.22	1.09	−0.75	0.26	−0.25	2.00	1.42	−1.54	−0.44	−1.21
2010	−0.85	−0.68	0.56	0.76	−0.60	0.51	1.89	−0.23	0.02	2.06	−0.34	1.46	−0.82	−0.24	0.70	1.26	−0.43	0.10	−0.68	2.03	1.75	−1.33	−0.47	−0.91
2011	−0.79	−0.60	0.35	0.48	−0.84	0.29	1.64	0.64	0.17	2.45	−0.49	1.09	−0.71	−0.08	0.52	0.78	−0.55	0.19	−0.84	1.66	1.95	−0.86	−0.63	−0.65
2012	−0.89	−0.71	0.13	0.67	−0.88	0.35	1.52	0.03	0.36	2.42	−0.37	0.15	−0.79	−0.35	0.39	0.23	−0.53	−0.13	−1.01	1.28	2.04	−1.15	−0.43	−0.83
2013	−0.80	−0.59	−0.02	0.25	−0.62	−0.03	1.92	−0.55	0.70	2.30	−0.30	−0.24	−0.62	−0.26	0.26	0.20	−0.38	−0.26	−1.48	0.93	2.40	−1.09	−0.25	−0.52
2014	−0.80	−0.80	0.00	0.34	−0.62	0.08	1.49	−0.36	0.36	2.34	−1.21	0.70	−0.64	−0.52	−0.14	−0.27	−0.21	−0.37	−1.23	0.77	3.19	−1.16	0.15	−0.68
2015	−0.79	−0.45	−0.17	0.32	−0.12	−0.16	1.85	−1.07	−0.13	1.52	−0.61	1.02	−0.60	−0.60	0.15	0.29	−0.17	−0.58	−1.58	1.03	2.23	−0.97	−0.48	−0.68
2016	−0.74	−0.63	−0.29	0.14	−0.34	−0.40	1.27	−0.96	−0.17	1.48	−0.95	−0.10	−0.74	−0.46	−0.21	−0.02	−0.25	−0.58	−1.38	0.36	2.41	−1.06	−0.37	−0.58
2017	−0.73	−0.62	−0.05	0.04	−0.28	0.00	1.72	−0.87	0.19	1.57	−0.70	−0.79	−0.65	−0.40	−0.12	0.33	−0.20	−0.45	−1.40	0.63	1.63	−1.11	−0.87	−0.29
2018	−0.68	−0.59	−0.29	0.08	−0.33	0.24	1.60	−0.59	0.33	1.16	−0.42	−0.92	−0.61	−0.51	−0.42	−0.26	0.02	−0.44	−1.33	0.49	1.60	−0.80	−0.77	−0.84
2019	−0.70	−0.55	−0.17	0.21	−0.12	0.12	1.36	−1.18	0.42	0.99	−0.79	−0.70	−0.60	−0.37	−0.14	−0.84	0.10	−0.41	−1.54	0.08	0.97	−0.87	−1.07	−0.79
2020	−0.85	−0.53	0.00	0.31	−0.38	−0.01	1.14	−0.93	0.24	0.51	−0.42	−0.92	−0.77	−0.31	−0.16	−0.27	−0.03	−0.50	−1.66	0.61	1.80	−0.80	−0.79	−0.67
2021	−0.87	−0.55	−0.15	0.24	−0.27	0.48	1.60	−1.79	0.32	1.90	−0.57	−1.51	−0.75	0.11	0.03	−0.18	0.23	−0.31	−1.50	0.00	1.50	−1.00	−0.66	−1.05
2022	−0.73	−0.46	0.01	−0.43	0.09	0.76	2.24	−1.50	0.47	1.95	0.07	−1.02	−0.49	−0.13	0.15	−0.28	0.24	−0.33	−1.46	0.04	1.91	−0.80	−0.66	−0.73

(b)

	India				Vietnam				Thailand				Indonesia				China				U.S.			
	Engi	Agglo	Insti	Secu	Engi	Agglo	Insti	Secu	Engi	Agglo	Insti	Secu	Engi	Agglo	Insti	Secu	Engi	Agglo	Insti	Secu	Engi	Agglo	Insti	Secu
2007	1.20	−0.77	−0.44	−0.09	0.73	0.36	0.15	−0.08	0.65	0.11	0.31	0.53	−0.81	0.90	0.41	1.59	0.12	−1.11	1.27	−0.08	0.89	−1.26	−1.16	−1.01
2008	0.80	−0.70	−0.43	0.27	1.75	2.23	−0.41	−1.65	0.03	0.50	−0.49	0.78	−1.01	1.67	−0.17	1.10	−0.44	0.37	2.43	0.21	−0.52	−1.43	−1.13	−1.15
2009	0.86	−0.68	−0.84	−0.31	1.01	1.40	−0.49	−0.59	0.34	0.83	−0.15	0.30	−1.24	1.40	−0.33	0.96	−0.40	0.13	2.21	0.36	−0.52	−1.22	−1.31	−1.48
2010	1.20	−0.78	−0.70	−0.16	0.94	1.16	−0.21	−0.70	0.67	0.67	−0.36	0.87	−1.47	1.28	−0.05	1.08	−0.91	−0.35	1.97	−0.17	−0.76	−1.36	−1.35	−1.57
2011	0.98	−0.59	−0.96	0.25	0.59	0.86	−0.55	−0.84	0.27	0.03	−0.66	−0.29	−1.52	1.23	1.08	1.37	−0.33	−0.38	2.11	−0.10	−1.26	−1.26	−1.37	−1.48
2012	1.23	−0.72	−0.78	0.12	−0.38	1.47	0.05	−0.41	−0.18	0.62	−0.24	0.16	−1.52	1.23	1.08	1.37	−0.91	−0.31	2.29	0.45	−1.56	−1.40	−1.25	−1.62
2013	0.82	−0.75	−0.84	−0.32	0.26	1.48	−0.45	−0.94	0.06	0.62	−0.32	0.09	−1.58	1.39	0.07	1.01	−0.53	−0.41	2.21	0.18	−1.06	−1.21	−1.23	−1.35
2014	1.40	−0.87	−0.82	−0.46	0.45	1.12	−0.36	−0.67	0.47	0.56	−0.22	0.40	−1.78	1.29	1.01	1.89	−0.46	−0.60	1.94	0.32	−1.51	−1.43	−1.20	−1.42
2015	1.02	−0.69	−0.70	0.14	0.94	1.36	−0.02	−0.47	0.47	0.73	0.27	0.48	−1.67	1.37	0.28	1.67	−0.24	−0.75	2.10	0.60	−1.20	−1.33	−1.07	−1.35
2016	1.46	−0.68	−0.66	−0.33	0.68	0.62	−0.13	−0.90	0.24	0.65	0.58	0.94	−1.71	1.30	0.55	2.12	−0.18	−0.78	1.84	0.00	−0.60	−1.28	−1.25	−1.48
2017	1.54	−0.70	−0.68	0.18	0.53	0.76	−0.16	−0.37	−0.05	0.38	0.42	0.53	−1.83	1.25	0.35	2.01	−0.19	−0.85	1.62	0.03	−0.64	−1.29	−1.30	−1.29
2018	1.73	−0.77	−0.52	−0.03	0.84	0.70	−0.05	−0.51	0.86	0.31	0.51	1.06	−1.33	1.31	0.81	2.32	−0.46	−0.73	1.96	0.47	−0.29	−1.28	−1.09	−1.10
2019	1.41	−0.86	−0.73	−0.17	0.94	0.74	−0.05	−0.84	0.03	0.26	0.19	0.41	−1.27	1.04	0.41	1.05	−0.07	−0.85	1.42	−0.26	−0.14	−1.31	−1.08658875	−1.02
2020	0.96	−0.96	−0.75	−0.48	0.69	0.47	−0.23	−1.27	0.54	0.34	−0.13	0.12	−1.07	1.11	0.29	1.17	0.32	−0.99	1.29	0.03	0.06	−1.24	−1.01	−0.90
2021	1.24	−0.84	−0.67	−0.66	0.50	0.26	−0.24	−0.92	1.11	0.50	0.05	0.20	−1.10	0.70	0.08	1.39	−0.26	−1.03	1.40	−0.07	0.30	−1.23	−1.17	−1.03
2022	0.91	−1.02	−0.64	−0.19	0.17	0.46	0.39	−0.41	0.39	0.60	0.57	0.89	−1.27	1.14	0.45	1.95	−0.13	−1.06	1.53	0.31	0.78	−1.17	−1.18	−0.69

Note: Agglo = Agglomeration, FDI = Foreign Direct Investment-led, Worker = Workers, Materi = Rww materials. Note: fa(p33,nfactors = X, fm = "ml",rotate = "promax") $scores by Program R. X = Number of eigne values greater than 1. Engi = Engineers, Inst = Institutions, Secu = Security. fa(p33,nfactors = X, fm = "ml",rotate = "promax") by Program R. X = Number of eigne values greater than 1. Source: Author's calculation.

When a factor score is 0.7, the variable has a strong relationship with the factor. When a factor score is 1.0, the variable is completely related to the factor.

Finally, India, however, is promising for investment in terms of engineers as human capital only in 2007 and 2008, but not in other areas.

5.3. Issues of Investment as "Brake Segment"

In this subsection, we reach the main conclusion of this paper that "engineers" are a brake segment as human capital for industrial agglomeration policies in the manufacturing industry. Factor scores of India are high at the factor consisting of both the items of difficult to secure technical/engineering staff and difficult to secure management-level staff.

5.3.1. Factor 1: Institutions

As shown in Figure 6, institutional issues were identified as the number one factor for investment issues in promising countries. These include 'Insufficient protection of intellectual property rights' (1), 'Foreign exchange and remittance restriction' (1), 'Unclear operation of legal system' (0.9), and 'Difficulty in collecting payments' (0.9). In terms of the operation of the legal system, 'Investment licensing procedures are complicated and unclear' (0.8) and 'Operation of the tax system is unclear' (0.7) were cited. 'Difficulty in raising funds' and 'Labour issues' (0.5) were also cited.

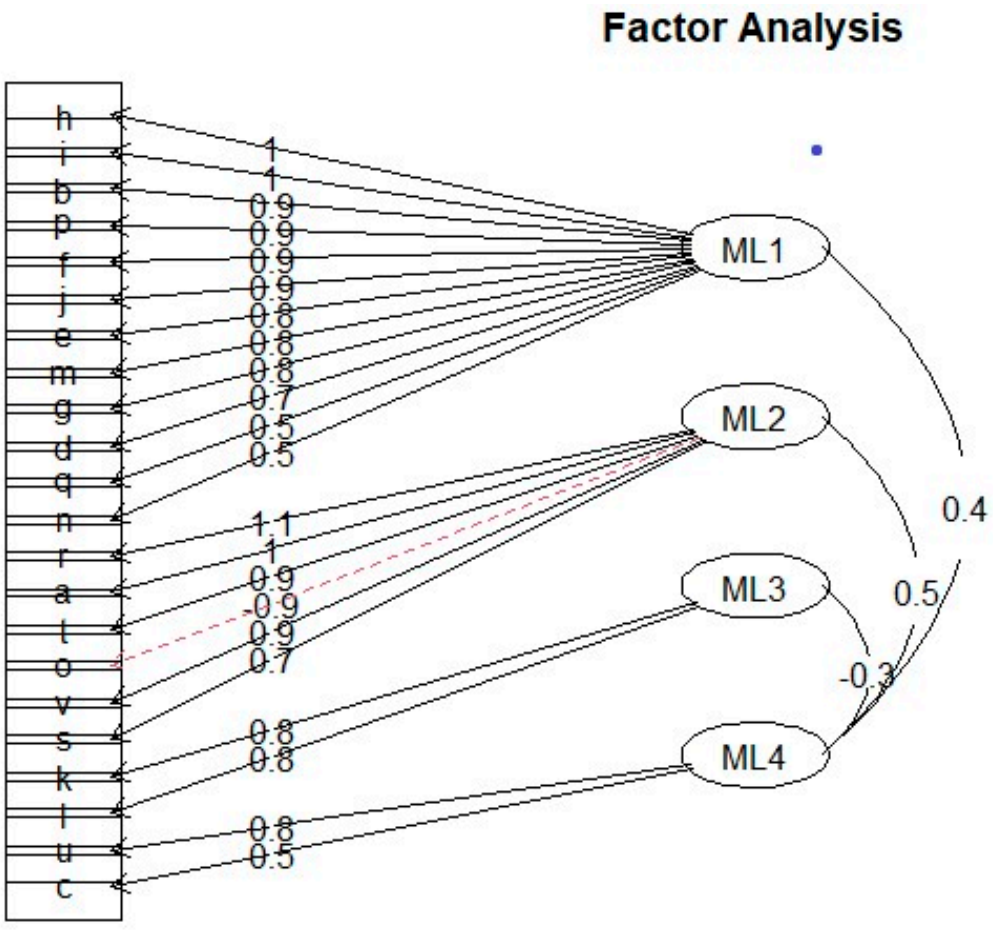

Figure 6. Factor loadings of investment issues. Note: The numbers above the arrows are factor loadings. Source: Author's calculation.

5.3.2. Factor 2: Industrial Agglomeration

The following industrial agglomeration factors were identified: 'Underdevelopment of local supporting industries' (1.1); 'Underdeveloped legislation' (1); 'Underdeveloped infrastructure' (0.9); 'Lack of information on investing countries' (0.9) and 'Lack of currency and price stability' (0.7).

5.3.3. Factor 3: Human Capital of Engineers

'Difficulty in securing local engineers' (0.8), and 'Difficulty in securing management-level personnel' (0.8).

5.3.4. Factor 4: Insecurity and Social Instability

The issue of 'insecurity and social instability' (0.8) is significant. Note that 'complexity of the tax collection system' (0.5) is included in Factor 4.

Next, this section examines the characteristics of each country's factor score regarding issues in investment. As shown in Table 5b, India alone has high scores for Factor 3, ranging from 0.80 to 1.73 between 1.2 in 2007 and 0.91 in 2022, indicating issues for engineers and managers. Vietnam has high scores for Factor 2, ranging from 0.86 to 2.23 between 2.23 in 2007 and 1.36 in 2018, indicating that industrial agglomeration was the issue. Thailand has no high scores for all factors.

Indonesia has high scores for both Factor 1 and Factor 4. Factor 1 ranged from 0.96 to 2.32 between 1.1 in 2007 and 1.59 in 2022, and Indonesia faced issues related to institutions and instability, such as social unrest and the tax collection system. Factor 4 ranged from 0.7 to 1.67 between 1.67 in 2007 and 0.9 in 2022, and Indonesia faced the problem of security. China has high scores for Factor 1, ranging from 1.27 to 2.43, indicating issues with the legal system. The US has no high scores for all factors between 2007 and 2018.

Table 6 is summary by combining the results of a and Table 5a,b India shows no promising item for investment and has issues with engineers and managers. Vietnam has issues with engineers only in 2007 and 2008 but has an abundance of low-wage labor and has been a good recipient of China's relocation. Thailand has no investment issues and is promising for the introduction of foreign direct investment. China has no promising points and has issues with its legal system. Indonesia has the issues of both institutions and security. The US has no investment issues and is promising for industrial agglomeration.

Thus, the issues related to investment in India are engineers and managers. The issues of engineers are the factors that hinder the industrial agglomeration of SEZs in India and are the "brake segment" for building industrial agglomeration.

The summary of issues and promising reasons by factor analysis in Table 6 gives policy recommendations as of 2022 to promote manufacturing agglomeration to the five target countries other than India. China has an issue on institutions but does not have an issue on engineers as human capital. Therefore, institutional reform is needed. Indonesia has both issues of institutions and security, so institutional reform and improvement of security are needed.

The US and Thailand will have no issues in 2022. In the US, the agglomeration item is promoting, and in Thailand, the FDI-led item is promoting. Both countries should continue developing engineers as human capital in order to promote the agglomeration of manufacturing industries. In Vietnam, the workers item is promoting, and the issue of engineers as human capital was resolved in 2022. Therefore, it is necessary to continue the current development of engineers as human capital. As a whole, the results in Table 6 indicate that the condition for the continuation of the process of industrial agglomeration in any country is the development of engineers as human capital.

Table 6. Summary of issues and promising reasons by factor analysis.

		Issues				Promising Items			
	Year	**Engineers**	**Agglomeration**	**Institutions**	**Security**	**Agglomeration**	**FDI-led**	**Workers**	**Raw Materials**
India	2007	1.2							
	2021	1.24							
	2022	0.91							
Vietnam	2007	1.74	2.23					3.09	
	2008	1.01	1.4					2.24	
	2011		1.47					1.63	
	2014		1.36						
	2022							2.24	
Thailand	2007						2.07		
	2018						1.15		
	2020	1.11					0.99		
	2021						1.9		
	2022						1.94		
Indonesia	2007			1.67	1.09				2.7
	2010			1.23	1.07				1.26
	2022			0.9	1.59				
China	2007			2.42					2.15
	2015								1.02
	2016								
	2022			1.26					
U.S.	2007					2.75			
	2022					1.9			

Source: Author's.

Next, the relationship between the "industrial agglomeration" factor of the promising reasons in Table 5a and the "four factors" of the issues in Table 5b will be regressed. The industrial agglomeration factor of the promising reasons for the investment environment in Table 5a is the objective variable, and the factor scores of the issues of "engineers", "agglomeration", "safety", and "institutions" in Table 5b are the independent variables. The results are as follows:

$$\text{Agglomeration} = 0.01007 - 0.49339\ \text{Engineers} - 0.34550\ \text{Agglomeration issue}$$

$$(0.158)\ (-6.744)\ ***\ (-4.479)\ ***$$

$$-0.28121\ \text{Institutions} - 0.41943\ \text{Security}$$

$$(-3.781)\ ***\ (-4.404)\ ***$$

(Adjusted R-squared is 0.6059, F-statistic is 37.52 on 4 and 91 DF, and p-value is 2.2×10^{16} and *** is significant at the 0 percent level. The numbers in parentheses are t-values).

The factor scores for the investment environment issues of engineers, agglomeration, safety, and institutions are negatively related to the factor scores for the promising reasons for industrial agglomeration. The coefficients for all independent variables are negative, indicating that these issues have a negative impact on agglomeration building. The coefficient for engineers was 0.493, the highest of the four factors. In other words, the issue of engineers was confirmed to have a negative impact on the promising reasons for industrial agglomeration.

In summary, first, this paper applied a spatial economic model to obtain Result 1. In the "manufacturing" sector, engineers and so-called skilled workers are included in the category of skilled labor. Engineers can be assumed to be human capital as a fixed factor of production rather than a variable factor of production. Therefore, the shortage of engineers in the manufacturing sector can be a brake on agglomeration.

Second, factor analysis using JETRO data found that investment-related costs can be categorized into three factors. The first factor of ML 1 is workers (general labor) in W1 and staff (general office work) in W4. The second factor of ML 2 is middle management (section chief) for W3 managers and managers (section chief) for W5. The third factor of ML 3 is engineers (intermediate technician) for (W2). The definition of engineers (intermediate technician) (W2) does not include so-called skilled workers. The paper supposes that ML 3 of "engineers" belongs to skilled labor as the human capital of fixed costs in the manufacturing industry. Integrating this result with Result 1 yields the following Result 2: the number of manufacturing agglomerations is inversely related to the shortage of engineers as "human capital".

Third, the factor analysis based on the manufacturing survey reveals that the factors that make up ML 3, where the factor scores for investment challenges in India are higher, are (k) Difficulty in securing local engineers (0.8) and (l) Difficulty in securing management-level personnel (0.8). In other words, India's investment challenge is the shortage of managers and engineers.

Taking the above three points together, we can judge that engineers as human capital belong to a brake segment. It is noted that we do not rule out the possibility that other segments, including managers, belong to a brake segment. In conclusion, the segment of "engineers" as human capital is one of the "brake segments".

6. Conclusions and Summary

India has not matched the size and success of East Asian industrial hubs, including China. Therefore, it is necessary to identify the missing segments of the investment environment for the introduction of foreign direct investment. The "segments" constitute the organization of agglomerations. Each segment then has a specific function in the process of building industrial agglomeration. We focus on the process of building segments in agglomeration formation. We define a "brake segment" as a segment that has the "function" of decelerating the speed of the process of building segments.

This paper identifies brake segments in the process of constructing segments of industrial agglomeration. A variant model of spatial economics and factor analysis of investment environment cost data yielded the result that the number of agglomerated firms is inversely related to the wages of engineers. Factor analysis and regression analysis of the six most promising investment destinations for Japanese firms using JBIC data were conducted on the investment challenges of foreign direct investment. The six countries are India, Vietnam, Thailand, Indonesia, China, and the US. Only India has a braking segment, due to the fact that it is the only one of these countries that has not increased its agglomeration as much as the others. As a result of the analyses, India's issue for the investment environment from 2007 to 2021 was the "engineer" segment. Hence, the conclusion of this paper is that the "brake segment" is "engineers as human capital".

As a policy recommendation, this paper provides steps that can be used for industrial agglomeration policies, as shown in Figure 2. First, the construction of agglomeration begins with an onset of the master switch. The master switch for manufacturing agglomer-

ation is to develop transportation infrastructure that reduces transport costs and attracts firms that produce heterogeneous goods with low elasticity of substitution. Second, the accelerator segment of agglomeration is the construction of industrial parks.

Third, identifying the braking segment is an essential proposition for policy makers in regions where the process of segment building is not yet in progress. Since the segment that acts as a brake in the agglomeration building process is engineers as human capital, the implication of this paper is to implement human resource development for engineers from "the initial stage". The process of building industrial agglomeration requires "the continuous development" of engineers as human capital. If the development of human capital becomes a bottleneck, the process of building industrial agglomeration will likely come to a standstill.

This approach can be used to determine the sequencing of official development assistance (ODA) in developing countries. First, ODA can be effective in building segments that will be turned on by a master switch to initiate an agglomeration policy. Second, human resource development of engineers needs to be implemented and continued from the beginning. Policy makers need to keep these two points in mind to initiate and continue the process of building the manufacturing agglomeration.

Table 7 summarizes the contributions of this paper. We linked spatial and sequence economics for tourism, urban agglomeration, and manufacturing. We focused on the segments that constitute the organization of agglomerations. We then identified the functions of the segments and specified master switch and accelerator segments. This paper identified the brake function.

Table 7. Linking spatial economics and sequencing economics.

Agglomeration	Location	Function	Segment	Spatial Economics	Sequencing Economics
Tourism industry	Osaka, Japan	(1) Master switch	commuter costs	Henkel et al. (2000)	Kuchiki (2021)
Urban agglomeration	Sapporo, Japan	(1) Master switch	commuter costs	Krugman (1991), Alonso (1964)	Kuchiki and Sakai (2023)
Manufacturing	Industrial hubs, China	(2) Accel	industrial zones	Helpman and Krugman (1985)	Kuchiki (2023)
Manufacturing	Industrial hubs, India	"(3) Brake"	"engineers"	Helpman and Krugman (1985)	"This paper"

Source: Author's.

The contribution of identifying segment functions can be explained below. Descriptive case studies on industrial agglomeration are numerous. The Oxford Handbook of Industrial Hubs and Economic Development by Oqubay (2020) provides a comprehensive analysis of the factors behind the success and failure of industrial agglomeration in Asia, Latin America, and Africa. The Oxford Handbook of Industrial Hubs and Economic Development by Lin and Oqubay provides a comprehensive analysis of the factors behind the success and failure of industrial agglomeration in Asia, Latin America, and Africa. Oqubay (2020) pointed out that Taiwan successfully pioneered an export processing zone at Kaohsiung Harbour, which aimed to attract investment and develop the manufacturing sector, especially for exports. Pietrobelli (2020) found that most examples in Latin America managed to create the conditions at the local level for private–private, public–private, and public–public collaboration. Oqubay and Kefale (2020) conclude that in Africa, effective mechanisms to develop production linkages remain weak in Ethiopia. Ahluwalia et al. (2018) argue that India lost its comparative advantage in labor-intensive production in the early stages of development due to very restrictive labor regulations in the formal sector and strong trade unions. Descriptive case studies on industrial agglomeration are numerous in this way.

However, this paper identified the factors that pose issues to industrial agglomeration from the following different perspectives. This paper contributes to the analysis of the

process of industrial agglomeration formation posed by Kanai and Ishida (2000). The process of agglomeration formation proceeds through the construction of the segments that structure the agglomeration. This paper identifies the role, or function, of these segments, and, in particular, identified segments that function to decelerate the speed of the process.

In particular, the paper contributes to providing a means by which the theory of "spatial economics" can be used in industrial agglomeration policy. The location theory of spatial economics presents the breaking conditions from symmetric equilibrium to agglomeration equilibrium. However, the process of transition to an agglomeration equilibrium does not initiate unless those conditions are satisfied. This allows policy makers in industrial agglomeration to specifically determine the sequence of policy implementation. This paper presented successful examples of segment sequencing in the case of official development assistance (ODA) in Vietnam and Thailand.

There are four issues to be addressed in the future of this paper. First, the most important task is to identify the segment with the function of innovation activity. This paper focuses on the process of agglomeration. Fujita and Kuchiki (2006) defined industrial clusters as consisting of two components: agglomeration and innovation activation. The study of the function of segments for innovation activation is essential under the fourth industrial revolution.

Second, the number of case studies needs to be increased and inductive conclusions strengthened. There are similar research issues for other industry agglomerations. Knowledge industry, tourism industry, and urban agglomeration are some possible examples. We need to increase the number of case studies in order to attain conclusions, especially with regard to the empirical study.

Third, although factor analysis was used as the statistical method, it would be worth exploring other statistical methods to identify the functions of segments.

Fourth, the validity of the spatial economic model on which the conclusions of this paper are based also needs to be reexamined. With regard to the theoretical model, we need to consider cases in which the assumed assumptions change.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Promising items of investment.

		China 2018	
	Survey Item	**# of Companies**	**Unit: %**
a	Excellent human resources	25	11.3
b	Cheap labor	29	13.1
c	Inexpensive parts and raw materials	16	7.2
d	A supply base for assembly manufacturers	53	24.0
e	Industrial agglomeration	49	22.2
f	Hubs of risk diversification in other countries	5	2.3

Table A1. *Cont.*

		China 2018	
	Survey Item	**# of Companies**	**Unit: %**
g	An export base to Japan	10	4.5
h	An export base to third countries	23	10.4
i	Advantages of raw material procurement	9	4.1
j	Current size of local market	141	63.8
k	Future growth potential of local markets	161	72.9
l	Profitability of local market	18	8.1
m	Product development hubs	16	7.2
n	Well developed local infrastructure	30	13.6
o	Well developed local logistics services	18	8.1
p	Preferential tax treatment for investment	9	4.1
q	Stable policies to attract foreign investment	1	0.5
r	Stable political and social conditions	6	2.7
Total		221	100.0

Note: 1. # oc companies = number of companies. 2. China is the first promising country in 2018 to invest. 3. For the factor analysis in this paper, 16 data sets from 2007 to 2022 were used for each of the tables of promising investment items and investment issues for China. For India, 16 data sets from 2007 to 2022 were also used. Similarly, 16 datasets were used for each of the other countries in Thailand, Vietnam, Indonesia, and the United States. Thus, the total number of data observed in each table used in the factor analysis is 96. Source: JBIC (2018).

Table A2. Issues of investment.

		China 2018	
	Survey Item	**# of Companies**	**Unit: %**
a	Underdeveloped legislation	18	8.1
b	Unclear operation of legal system	99	44.8
c	Insecurity and social instability	18	8.1
d	Operation of the tax system is unclear	39	17.6
e	Strengthening taxation	53	24.0
f	Control of foreign currency	45	20.4
g	Complicated and unclear investment licensing procedures	33	14.9
h	Insufficient protection of intellectual property rights	79	35.7
i	Foreign exchange and remittance restriction	62	28.1
j	Import regulations and customs procedures	53	24.0
k	Difficulty in securing local engineers	39	17.6
l	Difficulty in securing management-level personnel	43	19.5
m	Rise in labor costs	129	58.4
n	Labour issues	41	18.6
o	Intense competition with other companies	132	59.7
p	Difficulty in collecting payments	52	23.5
q	Difficulty in raising funds	11	5.0
r	Underdevelopment of local supporting industries	9	4.1
s	Lack of currency and price stability	14	6.3
t	Underdeveloped infrastructure	11	5.0
u	Complexity of the tax collection system	33	14.9
v	Lack of information on investing countries	6	2.7
Total		221	100.0

Note: 1. # of companies = number of companies. 2. China is the first promising country in 2018 to invest. 3. For the factor analysis in this paper, 16 data sets from 2007 to 2022 were used for each of the tables of promising investment items and investment issues for China. For India, 16 data sets from 2007 to 2022 were also used. Similarly, 16 datasets were used for each of the other countries in Thailand, Vietnam, Indonesia, and the United States. Thus, the total number of data observed in each table used in the factor analysis is 96. Source: JBIC (2018).

Appendix B

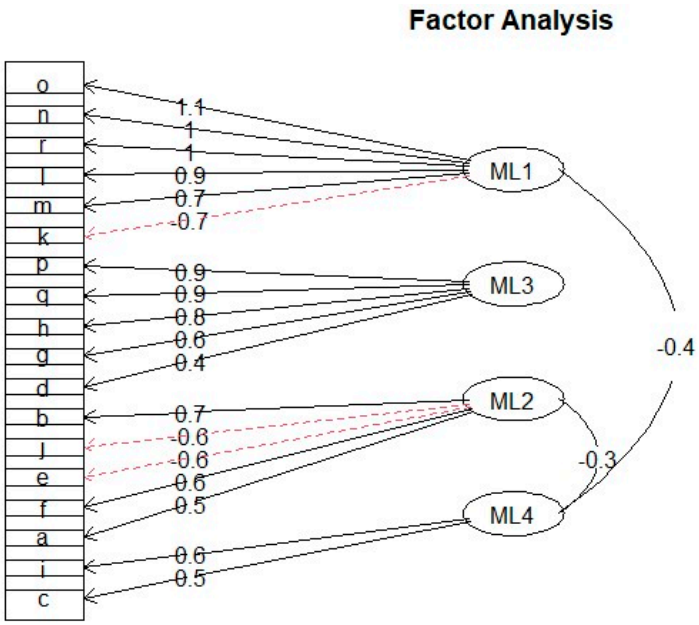

Figure A1. Source: Kuchiki (2023). Note: The numbers above the arrows are factor loadings.

Appendix C

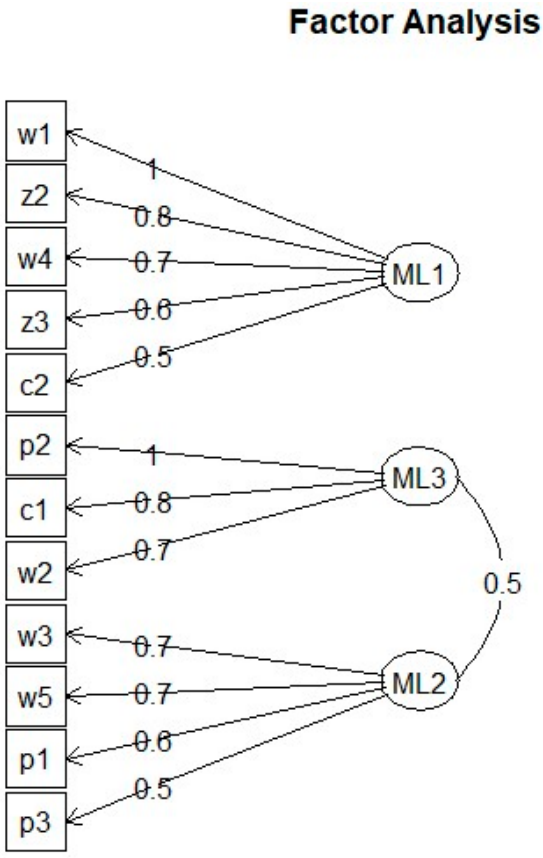

Figure A2. Source: Kuchiki (2023). Note: The numbers above the arrows are factor loadings.

Notes

[1] Data on GDP per capita are obtained from International Monetary Fund (2024).
[2] The facts of this section are based on Tran et al. (2003).
[3] Mitsui (2004) also introduced the facts.
[4] NESDB (2016) (Office of The National Economic and Social Development Board of Thailand and Office of The Eastern Seaboard Development Committee) outlined the Eastern Seaboard Development Program for industrial development in Thailand.
[5] Lecler (2002) explains the Eastern Seaboard Region Program.
[6] Shimomura (2000) and Ariga and Ejima (2000) provide the details.
[7] Watanabe (2004) examined how Official Development Assistance workd for agglomeration.
[8] Oqubay (2020) explains the Asian success in industrial hubs.
[9] Next IAS (2022) estimates the value of exports.
[10] The bill is subject to World Trade Organization standards.
[11] Other incentives include income tax exemption on income for up to 10 years, exemption from customs and excise duties, tax exemptions and surcharges. In September 2019, the Minimum Alternate Tax was reduced from 18.5% to 15%. See Dezan Shira & Associates (2023).
[12] Rathore (2023) studies the history of Indian special economic zones.
[13] See note 10 above.
[14] Factor analysis is performed by "Program R". The number of factors is the same as that of eigen values greater than 1. Rotation method is "romax method". Kuchiki (2023) explained it at p. 10.

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