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APPENDIX

A. Segments of infrastructure, institutions, human resources, and living conditions

Table A1: The segments of an urban agglomeration in sapporo city.

Category	Segment
Infrastructure	1. Railway: JR Sapporo Station 1. Shinchitose International Airport
Human resources	Population Unskilled labor
	Engineers Managers
Institutions	1. JR timetable revision
Living conditions	2. Development surrounding JR Sapporo Station 2. Ultra-high-rise buildings for housing in Chuo District 2. Ultra-high-rise buildings for office in Chuo District Schools: 15 Universities Hospitals
Living conditions: Cultural aspects	Sports: Baseball and Soccer football Musiums and parks Restaurants and bars

Source: Author's Illustration based on Kuchiki (2021b).

Table A2: The segments of ICT agglomeration.

Category	Segment
Human resource	Development and invitation: 1. Skilled workers (Fujita & Thisse (2003) 1. Researchers for patents 1. Persons in charge of commercialization
Infrastructure	Parks, sub-parks Railways Airport Communication Water Electricity roads
Institutions	2. Funding support RIS, UIGLs Laws and regulations
Living condition	Housing and entertainment Hospitals and schools The environment

Source: Author's Illustration based on Kuchiki (2021b).

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Table A3: The segments of a tourism agglomeration in Osaka.

Category	Segment
Infrastructure	1. Kansai International Airport: Low-cost carriers Railway Port Communication, Electricity, Water
Human resources	Population Unskilled labor Engineers Managers
Institutions	Laws and regulations Land ownership
Living conditions	2. Entertainment: Universal Studio Japan Hospitals and schools
Living conditions: Cultural aspects	Dynasty: Heian Dynasty Food: Octopus dumplings Music: Kawachi folk song History: Osaka Castle Textile: Senshu Towel Painting: the Korin school Nakamurahochu Resort: Kyoto, Kobe Alcholic beverage: Local sake Akishika

Source: Author's Illustration based on Kuchiki (2021b).

Table A4: The segments of a manufacturing industry agglomeration.

Category	Segment
Infrastructure	Transport: 1. Port, Highways, Railway, Airport 1. Industrial zone, Electricity, Water Communication
Human resources	2. Unskilled labor, Engineers Managers
Institutions	3. Deregulation 3. Preferential treatments (tax incentives, etc.) 3. One-stop services
Living condition	Laws and regulations Housing International schools Hospitals Entertainment & shopping

Source: Author's Illustration based on Kuchiki (2020b).

B. Dummy variable method

Table B1: Trends changes of dummy variables (T-values).

	Sapporo	Otaru	Ishikari	Ebetsu	Kitahiroshima
1994	5.34	5.56	2.92	8.25	4.91
1995	6.26	6.11	3.05	8.6	5.42
1996	6.67	6.59	3.02	7.09	5.83
1997	6.2	6.91	2.95	6	6.08
1998	5.39	6.29	3.45	3.49	5.64
1999	4.51	5.34	3.43	2.82	5.06
2000	3.48	4.07	2.92	1.32	4.21
2001	2.85	2.87	2.8	1.78	3.42
2002	2.15	1.94	2.8	1.01	2.47
2003	1.33	0.98	2.84	0.26	1.65
2004	0.38	0.03	2.94	-0.47	0.85
2005	-0.56	-0.98	3.05	-1.2	-0.02
2006	-1.48	-1.94	1.25	-2.14	-0.93
2007	-2.44	-2.78	-0.09	-2.85	-1.9
2008	-3.34	-3.49	-1.26	-3.48	-2.95
2009	-4	-3.93	-2.38	-3.94	-3.96
2010	-4.44	-4.19	-3.52	-4.18	-4.93

2011	-4.57	-4.22	-4.7	-4.6	-5.46
2012	-4.66	-4.28	-5.71	-4.43	-5.97
2013	-4.59	-4.61	-6.49	-4.15	-6.08
2014	-4.45	-4.63	-6.6	-3.74	-5.69

Source: Author's calculations.

Table B2: The population of sapporo station.

	S	d1	d2	d3	-	d22
1990	1671742	0	0	0		0
1991	1694988	0	0	0		0
1992	1714488	0	0	0		0
1993	1728466	0	0	0		0
1994	1740534	1	0	0		0
1995	1757025	1	1	0		0
1996	1774540	1	1	1		0
1997	1791221	1	1	1		0
1998	1803546	1	1	1		0
1999	1812029	1	1	1		0
2000	1822368	1	1	1		0
2001	1834684	1	1	1		0
2002	1848276	1	1	1		0
2003	1862361	1	1	1		0
2004	1872703	1	1	1		0
2005	1880863	1	1	1		0
2006	1889460	1	1	1		0
2007	1895901	1	1	1		0
2008	1900815	1	1	1		0
2009	1907404	1	1	1		0
2010	1913545	1	1	1		0
2011	1922729	1	1	1		0
2012	1930207	1	1	1		0
2013	1938331	1	1	1		0
2014	1945504	1	1	1		0
2015	1952356	1	1	1		1
2016	1958405	1	1	1		1

Source: Author's illustration.

The estimated equations of the dummy-variable method can be described as follows:

$$Y_i = a_1 + a_2 T_i + a_3 D_{m,1989+j} + e_i$$

(i = 1, 2, ….., 30, and m = 1, 2, …., 21, 22)

where $Y_i, T_i D_{m,1989+j}, a_p (p = 1, 2, ---, 21, 22)$, and ei denote the number of the population, year, dummy variables, constant coefficients, and an error term, respectively.

Here the dummy variables for different intercepts (or intercept shift) are set as follows: Regarding $D_{m,1989+j}$

$D_{m,1989+j} = 0$ if j < m+4,

$D_{m,1989+j} = 1$ else,

where i = 1, ~, 30, and m= 1, 2,….., 21, 22.

Illustrating the case of m = 1 of the number of the population of Sapporo City as is shown below, a dummy variable is , $D_1,^{1989+j}$

$$Y_i = a_1 + a_2 T_i + a_3 D_{1,1989+j} + e_i$$

where i=1,….,30, and D_1, and $D_{1,1989+j}$=0, if j<1+4, and $D_{1,1989+j}$=1, else. Regressing Y of the number of the population on the dummy variable, $D_{1,1994}$, carries out test by t value, and obtains 5.34 as shown in the Table B2. Table B1 shows the t-values of the dummy-variable analyses on the numbers of the population of Sapporo, Otaru, Ishikari, Ebetsu, and Kitahiroshima cities.

C. Derivation of the condition of symmetry breaking

First, we obtain the first order condition of the following problem:

Minimize $\sum_{r=1}^{2} \int_0^{n_r} p_{rk}(i) m_{rk}(i) di$,

subject to $[\sum_{r=1}^{2} \int_0^{n_r} m_{rk}(i)^{\frac{\sigma-1}{\sigma}} di]^{\sigma/(\sigma-1)}$

Then, maximizing the utility (1), we obtain

$$P_k M_k = \mu$$

(A1) $m_{rk}(\mathrm{i}) = (p_{rk}(\mathrm{i})^{-\sigma} / P_k^{-\sigma}) M_k$ for k = 1, 2, and r = 1, 2,

$R_1 = Y_1 - \left(\mu + \theta\lambda L^m/2\right)$, and

$R_1 = Y_2 - \left[\mu + \theta(1-\lambda) L^m/2\right]$

where the price index is as follow:

$P_k = [\sum_{r=1}^{2} \int_0^{n_r} p_{rk}(\mathrm{i})^{1-\sigma} di]^{1/(1-\sigma)}$, for k = 1, 2

Next, consider a particular firm producing a specific variety at region k. The firm trade one good each and incur variable costs c, W_k is the wage of skilled labor (L^m) and a fixed cost $W_k F$ of human capital. Here we assume F=1 for simplicity. A firm producing variety i in region k maximize profits

(A2)

$$\pi_k(\mathrm{i}) = (\mathrm{p}_{kk}(\mathrm{i}) - \mathrm{c})\,\mathrm{m}_{kk}(\mathrm{i})(\lambda_k\,\mathrm{L}^m + \mathrm{L}^a/2) + (\mathrm{p}_{kr}(\mathrm{i}) - \tau\,\mathrm{c})\,\mathrm{m}_{kr}(\mathrm{i})(\lambda_r\,\mathrm{L}^m + \mathrm{L}^a/2) - w_k$$

for k = 1, 2, r = 1, 2, r≠k

where τ is the "iceberg" form of transport costs, λ_1 and λ_2 represent region 1's share of manufacturing and region 2, respectively.

The first-order condition gives the equilibrium price.

(A3) $p_{kk}(\mathrm{i}) = \mathrm{p} = \sigma\,\mathrm{c}/(\sigma - 1)$, $p_{kr}(\mathrm{i}) = \tau\,\mathrm{p}$

The price index is

(A4) $P_k = p(\mathrm{n}_k + \varphi n_n)^{1/1(\sigma-1)}$, for k = 1, 2, r = 1, 2, r ≠k

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

Substituting (A1), (A3), and (A4) in (A2) obtains the firm's profits at region 1 and 2:

$$\pi_k(\mathrm{i}) = \pi_{kk}(\mathrm{i}) + \pi_{kr}(\mathrm{i}) - \mathrm{w}_k = (\mu/\sigma[\{(\lambda_k\,\mathrm{L}^m + \mathrm{L}^a/2)/(\mathrm{n}_k + \varphi\,\mathrm{n}_r)\} + \{\varphi(\lambda_r\,\mathrm{L}^m + \mathrm{L}^a/2)/(\varphi\,\mathrm{n}_k + \mathrm{n}_r)\}] - \mathrm{w}_k$$

for k =1,2, r=1, 2, r≠k.

The model supposes that there is the free entry and exit of firms in response to profits or losses. Therefore, the zero-profit condition implies that the equilibrium wage of the varieties is

$$w_k = (\mu/\sigma)\{[(\lambda_k\,\mathrm{L}^m + \mathrm{L}^a/2)/(\mathrm{n}_k + \varphi n_n)] + [\varphi(\mathrm{n}_k\mathrm{L}^m + \mathrm{L}^a/2)/(\varphi n_k + \mathrm{n}_r)]\}$$

where $\lambda_k = \lambda$, and that $\lambda_r = 1 - \lambda$.

Using the equations above, the indirect utility function of a skilled worker living in region k, Vk, is given by

$V_k = w_k + \theta\lambda_k L^m/2 - \mu \ln P_k + (\ln\mu - 1)$.

The difference between two regions is

(A5)

$$\Delta V(\lambda) = V_1 - V_2 = (\mu/(\sigma-1))[\ln(\lambda - \varphi\lambda + \varphi)/(\varphi\lambda - \lambda + 1)] + [\mu(1-\varphi)(1-\varphi-\nu-\nu\varphi)(1-2\lambda)]/[2\nu\sigma(\lambda - \varphi\lambda + \varphi)(\varphi\lambda - \lambda + 1)] - \theta(\lambda - 1/2)\,\mathrm{L}^m$$

where $\nu \equiv L^m/N(\mathrm{N} = \mathrm{L}^m + \mathrm{L}^a)$ is skilled labor ratio.

D. Data Source

y	p	q	h	r	s	t	g	d
1990	97201	47758		164568	47924	1671742		
1991	99305	48990		163475	48985	1694988		
1992	102815	50436		162148	49980	1714488		
1993	106798	51613		161033	51207	1728466		
1994	111099	52706		159993	52074	1740534		
1995	115495	53537		158544	53019	1757025		
1996	116745	54332		157082	53660	1774540		
1997	118805	55591		155784	54012	1791221		
1998	120455	56405		154768	54428	1803546		
1999	121512	57144		153550	54806	1812029		
2000	123877	57731		152063	55480	1822368		
2001	123071	58743		150244	55578	1834684		
2002	123583	59040		148791	55805	1848276		
2003	123902	59516		147124	56023	1862361		
2004	124051	60253	82527	145493	56343	1872703		
2005	125601	60677	84391	143490	61358	1880863	13323	8775
2006	123917	61029	84932	141322	61421	1889460	14104	8665
2007	123537	61174	85494	139267	61404	1895901	13781	8644
2008	123054	60966	86047	137120	61286	1900815	12995	8688
2009	122568	60864	85643	135168	61195	1907404	13014	8534
2010	123722	60353	86393	133168	61077	1913545	12605	8509
2011	121705	60534	88531	131444	60717	1922729	12165	8480
2012	121385	60305	91575	129947	60533	1930207	13041	8693
2013	120802	59908	93152	127793	60081	1938331	13559	8786
2014	120335	59662	93313	125540	59449	1945504	13416	8789
2015	120636	59064	95288	123367	59141	1952356	13653	8997
2016	119250	59205	97652	121268	58982	1958405	13880	9056
2017	118979	58863	99463	119352	58581	1962918	15271	9398
2018	118971	58713	99593	117042	58363	1965940	15846	9559
2019	119510	58375	98383	114919	58288	1970052	15264	9459

Data source

p: the population of Ebetsu city population https://www.city.ebetsu.hokkaido.jp/uploaded/attachment/42671.pd
q: the population of Kitahiroshima city https://www.city.kitahiroshima.hokkaido.jp/hotnews/detail_sp/00127308.html#01
h: the number of passengers at JR Sapporo per day https://www.city.sapporo.jp/sogokotsu/kotsutaikei/documents/1_pdfsam_data2019.pdf
r: the population of Otaru city https://www.city.otaru.lg.jp/sisei_tokei/reiki_tokei_siryo/toukei/toukeisho.data/toukeisyo_7177KB.pdf
s: the population of Ishikari city http://www.city.ishikari.hokkaido.jp/soshiki/soumu/3227.html
t: the population of Sapporo city https://www.city.sapporo.jp/toukei/tokeisyo/02populationir1.html unit: one person, accessed on Nov. 22,2020.
g: number of tourists to Sapporo https://www.city.sapporo.jp/keizai/kanko/statistics/statistics.htm unit: thousand persons, accessed on Nov. 22, 2020 (fiscal year).
d: the number of passengers per day at Otaru station https://www.city.otaru.lg.jp/sisei_tokei/reiki_tokei_siryo/toukei/toukeisho.data/H22toukeisyo.pdf(various years) unit: one person, accessed on Nov. 22, 2020 (fiscal year)