Do More Productive Firms Locate New Factories in More Productive Locations? An Empirical Analysis Based on Panel Data of Japan's *Census of Manufactures*

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RESEARCH QUESTIONS

Which factors explain factories' productivity level?

- **Is factories' productivity affected by firm-specific characteristics?**

  or

- **Is factories' productivity affected by location-specific characteristics?**

  or

- **Both?**

Which factors are more important?

How location-specific characteristics affect firm decisions about where to locate factories?

LITERATURE FOCUSING ON FIRM-SPECIFIC CHARACTERISTICS

Productivity analysis (e.g., Bartelsman and Doms 2000)

A consensus among researchers on productivity is that differences in productivity across factories within the same industry are caused by factory-specific factors such as human capital and capital vintage, as well as the characteristics of the firm (in terms of R&D, IT, FDI, exports, etc.) to which the factory belongs.

However, studies in this vein cannot explain the phenomenon of industry concentration because they do not take into account location-specific factors such as agglomeration effects.

LITERATURE FOCUSING ON LOCATION-SPECIFIC CHARACTERISTICS

Regional economics (e.g., Henderson, 2003)

Assuming firm homogeneity within a region and industry, researchers in regional economics have looked for regional factors which may explain differences in productivity between factories within the same industry, such as agglomeration effects due to natural cost advantages and local knowledge spillovers.

However, studies in this vein cannot explain why there may be two or more factories owned by the same firm operating in different locations, because such studies usually do not fully take account of firm heterogeneity arising from firm characteristics.

RECENT RESEARCH

1.Theoretical research

Baldwin and Okubo (2006) presented a theoretical model combining a new economic geography model and a Melitz-style model of heterogeneous firms, in which self-sorting occurs and productive factories choose to locate in productive areas. Their result suggests that firm-specific factors and regional factors affect each other through the endogeniety of location decisions.

2. Empirical research

Shaver and Flyer (2000), using start-up data of foreign-owned factories in the United States, have shown that if firms are heterogeneous, they will not cluster geographically despite the existence of agglomeration economies. Their results suggest that more productive foreign-owned firms tend to locate their activities in less productive regions.

OBJECTIVE OF THE PAPER

To the best of our knowledge, there have been no studies examining simultaneously the role of firm-specific and location-specific characteristics in explaining differences in factory-level productivity and the location decision of firms.

We test whether more productive firms tend to choose more productive locations.

MEASURING FACTORIES' TFP LEVEL

$$\ln TFP_{i,t} = (\ln Q_{i,t} - \overline{\ln Q_t}) - \sum_{n=1}^{N} \frac{1}{2}(s_{n,i,t} + \overline{s_{n,t}})(\ln X_{n,i,t} - \overline{\ln X_{n,t}})$$

Following Good, Nadiri, and Sickles (1997), we measure the TFP level of factory *i* in year *t* in a certain industry in comparison with the TFP level of a hypothetical representative factory in year *t* in that industry.

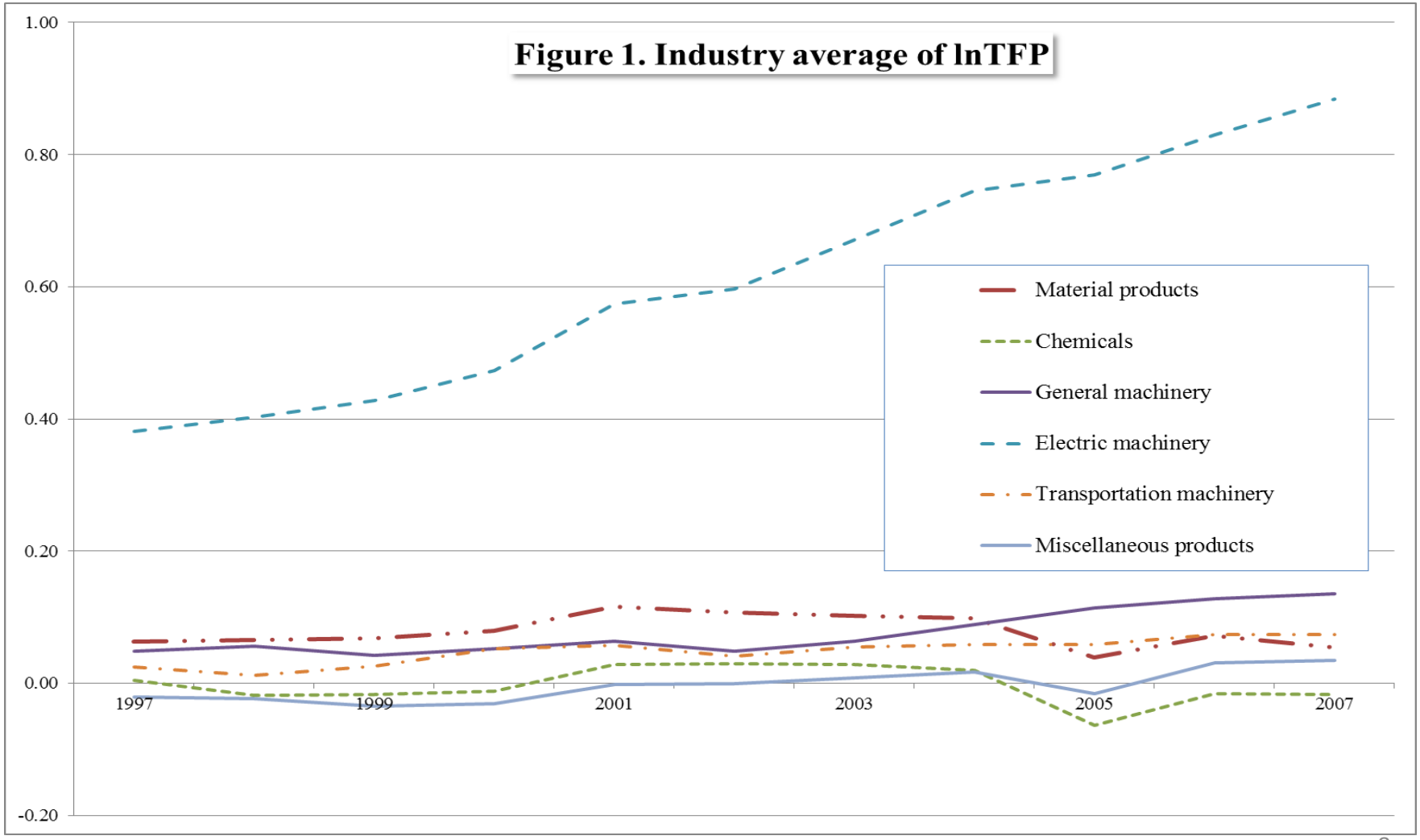
Output: the sum of shipments, the revenue from repairing and fixing services, and revenues from performing subcontracted work

Labor input: the product of the number of employees and the industry average of annual working hours

Capital input: the product of the nominal book value of tangible fixed assets (taken from the *Census of Manufactures*) and the book-to-market value ratio for each industry

Intermediate input: the sum of the material, fuel, and electricity expenditures and subcontracting expenses for consigned production.

INDUSTRY AVERAGE OF TFP LEVEL



ESTIMATION OF FIRM AND LOCATION EFFECTS

$$\ln TFP_{i,t} = \beta_{a1} Age_{i,t} + \beta_{s1} Scale_{i,t} + \sum_{l'} \beta_{l'} DL_{l'}(i,t) + \sum_{f'} \beta_{f'} DF_{f'}(i,t) + \sum_{t'} \beta_{t'} DY_{t'}(t) + R_{i,t}$$

The TFP level in year *t* of factory *i*, which belongs to firm *f* and is located in location *l*, is assumed to be determined by the following factors: factory age and size, firm effects (measured by a dummy for the firm to which the factory belongs; DF), location effects (measured by a location dummy at the city/town/village level; DL), and industry specific effects (measured by a dummy for the industry to which the factory belongs: DI).

In order to take account of the possibility that firm and location effects may differ across industries, we estimate the above equation separately for six manufacturing subsectors. We assume that location and firm effects are constant overtime.

DATA

Data source: Individual factory and firm level panel data of Japan's *Census of Manufactures* conducted by the Ministry of Economy, Trade and Industry (METI) for the period from 1997 to 2007.

year	Total number of factories	Number of factories, of which TFP were measured	Number of factories, of which TFP data were used for measuring firm effects and location effects
1997	358,246	142,872	7,393
1998	373,713	141,379	14,615
1999	345,457	134,554	22,174
2000	341,421	130,432	22,094
2001	316,267	43,597	17,592
2002	290,848	41,657	16,818
2003	504,503	40,780	16,525
2004	270,905	40,483	17,393
2005	468,840	110,799	21,553
2006	258,543	40,837	15,168
2007	258,232	41,615	17,945
Total	3,786,975	909,005	189,270

Table 3. Number of Cities/Wards/Towns/Villages (Year=2005)			
	Prefecture	Total number of cities, wards, towns and villages	Total number of cities, wards, towns and villages, of which TFP were measured
1	Hokkai-do	186	108
2	Aomori	40	31
3	Iwate	35	31
4	Miyagi	36	34
5	Akita	25	21
6	Yamagata	35	32
7	Fukushima	59	49
8	Ibaragi	44	44
9	Tochigi	31	31
10	Gunma	38	33
11	Saitama	70	68
12	Chiba	56	52
13	Tokyo	62	52
14	Kanagawa	50	46
15	Niigata	30	29
16	Toyama	15	15
17	Ishikawa	19	17
18	Fukui	17	15
19	Yamanashi	28	23
20	Nagano	81	57
21	Gifu	42	40
22	Shizuoka	38	30
23	Aichi	76	72
24	Mie	29	27
25	Shiga	26	23
26	Kyoto	36	31
27	Osaka	66	62
28	Hyogo	48	47
29	Nara	39	24
30	Wakayama	30	19
31	Tottori	19	16
32	Shimane	21	16
33	Okayama	27	25
34	Hiroshima	30	28
35	Yamaguchi	20	19
36	Tokushima	24	19
37	Kagawa	17	17
38	Ehime	20	19
39	Kouchi	34	19
40	Fukuoka	76	68
41	Saga	20	18
42	Nagasaki	23	15
43	Kumamoto	47	39
44	Oita	18	16
45	Miyazaki	30	22
46	Kagoshima	45	30
47	Okinawa	41	20
	Total	1,899	1,569

DESCRIPTIVE STATISTICS OF FIRM AND LOCATION EFFECTS

1) Location effects

Industry	Number of observations	Mean	Standard deviation	Min	Median	Max
Material products	11,588	-0.005	0.277	-2.233	0.000	1.589
Chemicals	5,045	-0.056	0.502	-3.194	-0.035	2.629
General machinery	8,476	0.106	0.504	-2.660	0.040	2.572
Electric machinery	8,827	-0.183	0.396	-2.347	-0.178	1.901
Transportation machinery	5,090	-0.001	0.297	-1.675	0.000	1.138
Miscellaneous products	12,104	-0.018	0.388	-2.529	0.003	2.104
Total	51,130	-0.025	0.404	-3.194	-0.012	2.629

2) Firm effects

Industry	Number of observations	Mean	Standard deviation	Min	Median	Max
Material products	32,990	-0.076	0.322	-1.917	-0.065	2.208
Chemicals	8,263	0.011	0.561	-2.509	0.000	3.404
General machinery	19,771	-0.010	0.512	-2.789	0.000	3.754
Electric machinery	17,737	-0.135	0.428	-2.536	-0.084	2.032
Transportation machinery	8,752	0.001	0.285	-1.326	0.000	1.445
Miscellaneous products	32,123	-0.080	0.536	-3.257	-0.069	2.573
Total	119,636	-0.063	0.454	-3.257	-0.024	3.754

CORRELATION COEFFICIENTS BETWEEN FIRM VARIABLES

Table 5. Correlation Coefficients between Firm Variables

	Variables	1	2	3	4	5	6
1	Firm effects	1					
2	∑shipment of the firm	0.134	1				
3	Number of employees	0.051	0.851	1			
4	Number of factories of the firm	0.022	0.465	0.512	1		
5	Weighted average of ln*TFP* of the firm	0.298	0.258	0.170	0.040	1	
6	lnTFP derived from Basic Survey Data*	0.076	0.329	0.233	-0.008	0.563	1

Note: 1. All the coefficients are statistically significant at 1% level.

CORRELATION COEFFICIENTS BETWEEN LOCATION VARIABLES

Table 6. Correlation Coefficients between Location Variables

	Variables	1	2	3	4	5	6	7
1	Location effects (by location and by subsector)	1						
2	ln(Total shipment of the same subsector in the location)	0.087	1					
3	ln(Number of factories in the same subsector in the location)	0.081	0.637	1				
4	Wage premium	0.059	0.265	0.158	1			
5	ln(Land price of the city)	0.061	0.248	0.257	0.567	1		
6	Weighted average of ln*TFP* of factories in the same subsector of the location	0.065	0.197	-0.076	0.107	0.067	1	
7	ln(Industry agglomeration)	0.088	0.855	0.579	0.365	0.504	0.184	1

Note: All the coefficients are statistically significant at 1% level.

WHICH FACTORS IS IMPORTANT IN EXPLAINING FACTORIES' PRODUCTIVITY?

Results of ANOVA: Partial Sum of Squares

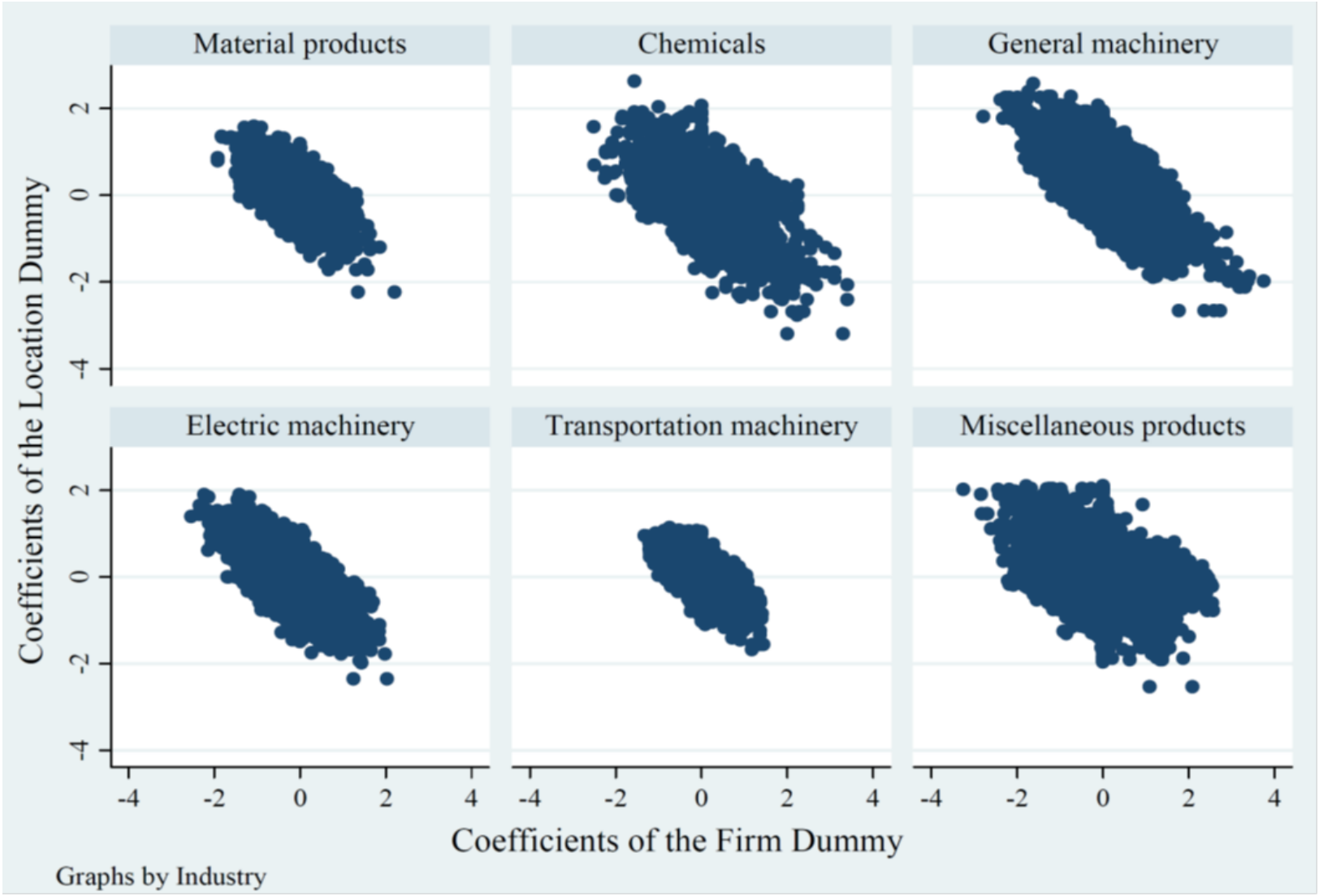
Source	Material products	Chemicals	General machinery	Electric machinery	Transportation	Miscellaneous
Model	2,687.7	1,626.9	1,340.6	2,289.8	490.7	4,134.1
Age of the factory	2.8	1.8	0.9	0.0	0.2	6.1
ln(number of employees)	3.8	0.2	1.1	0.6	2.8	4.4
Location	338.9	363.9	254.4	284.9	144.2	415.3
Firm	1,920.0	940.5	902.1	963.8	269.9	2,605.0
Industry (JIP)	7.6	10.3	0.5	1.8	2.2	2.9
Year	35.7	11.1	12.1	343.1	2.9	4.6
Residual	2,079.1	696.3	888.5	1,121.1	407.1	1,912.1
Total	4,766.8	2,323.2	2,229.1	3,410.9	897.8	6,046.1

WHICH FACTOR IS MORE IMPORTANT FOR EXPLAINING FACTORIES' PRODUCTIVITY? (CONTD.)

The estimation results show that both location and firm effects are important in explaining factories' productivity level. About 40-50 percent of the total variation can be explained by these two effects.

The result also shows that in all the manufacturing subsectors, the partial sum of squared deviations of the firm effects is greater than the partial sum of squared deviations of the location effects. Thus, to which firm a factory belongs is a more important determinant of this factory's TFP level than in which location this factory is located.

SCATTER DIAGRAMS OF LOCATION EFFECTS AND FIRM EFFECTS



CORRELATION COEFFICIENTS BETWEEN LOCATION EFFECTS AND FIRM EFFECTS

Industry	Correlation Coeffcients
Material products	-0.438
Chemicals	-0.491
General machinery	-0.644
Electric machinery	-0.667
Transportation machinery	-0.620
Miscellaneous products	-0.205

Note: All the coeffcients are statistically significant at 1% level.

There is a statistically significant negative correlation between firm and location effects for all six manufacturing subsectors. This result suggests that more productive firms set up their factories in less productive locations.

CORRELATION COEFFICIENTS BETWEEN FIRM EFFECTS AND LOCATION VARIABLES

		Variables	1	2	3
Material products	1	Firm effects	1		
	2	Wage premium	0.0189***	1	
	3	Land price of the city	0.0120**	0.5709***	1
Chemicals	1	Firm effects	1		
	2	Wage premium	0.010	1	
	3	Land price of the city	0.0171**	0.4963***	1
General machinery	1	Firm effects	1		
	2	Wage premium	0.0111*	1	
	3	Land price of the city	-0.0183***	0.06145***	1
Electric machinery	1	Firm effects	1		
	2	Wage premium	0.0483***	1	
	3	Land price of the city	0.0316***	0.6373***	1
Transportation machinery	1	Firm effects	1		
	2	Wage premium	0.0156*	1	
	3	Land price of the city	0.0585***	0.5432***	1
Miscellaneous products	1	Firm effects	1		
	2	Wage premium	0.0525***	1	
	3	Land price of the city	0.1253***	0.6517***	1

NUMBER OF NEW FACTORIES

Table 10. Number of Observations of Factory Startups in Location Choice Estimation

Industry	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Material products	113	44	44	34	20	36	36	62	50	87	526
Chemicals	23	11	15	10	13	10	9	10	6	24	131
General machinery	44	19	21	18	19	17	10	21	15	54	238
Electric machinery	50	26	12	21	31	30	35	21	39	29	294
Transportation machinery	23	6	11	2	11	13	25	17	28	36	172
Miscellaneous product	156	38	39	43	44	42	24	47	45	139	617
Total	409	144	142	128	138	148	139	178	183	369	1,978

Notes: In our estimation, we used data of new factories, for which both the location effect data and the firm effect data are available. Therefore, the number of observations is much smaller than the number of all the startups.

LOCATION CHOICE MODEL 1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Location effect	0.146 **				0.122 *	0.128 **	-0.0318
	(0.063)				(0.063)	(0.064)	(0.070)
Wage premium (t-1)		1.14 ***			1.13 ***		
		(0.153)			(0.153)		
ln(Land price of the city) (t-1)			0.169 ***			0.167 ***	
			(0.025)			(0.025)	
Indusrty agglomeration (t-1)				0.405 ***			0.406 ***
				(0.014)			(0.014)
ln(1+Number of factory of the same firm	3.65 ***	3.62 ***	3.61 ***	3.64 ***	3.62 ***	3.61 ***	3.64 ***
in the same prefecture (t-1))	(0.068)	(0.068)	(0.069)	(0.071)	(0.068)	(0.069)	(0.071)
R-squared	0.105	0.107	0.107	0.14	0.107	0.107	0.14
Log-likelihood	-1.26E+04	-1.25E+04	-1.22E+04	-1.12E+04	-1.25E+04	-1.22E+04	-1.12E+04
Number of observations	1,887,285	1,853,868	1,791,607	1,755,951	1,853,868	1,791,607	1,755,951

Estimation result 1(Manufacturing sector):

The estimated coefficients on the location effect are positive in most cases and significant. This result provides a strong evidence suggesting that firms tend to prefer more productive locations.

LOCATION CHOICE MODEL 2

	(1)		(2)		(3)		(4)	
Location effect	3.57	***	3.44	***				
	(0.230)		(0.235)					
Location effect*Firm effect	-1.54	***	-1.49	***				
	(0.101)		(0.103)					
Indusrty agglomeration (t-1)					0.244	***	0.261	***
					(0.062)		(0.063)	
Indusrty agglomeration(t-1)*Firm effect					0.076	***	0.066	**
					(0.028)		(0.028)	
ln(1+Number of factory of the same firm			3.65	***			3.64	***
in the same prefecture (t-1))			(0.068)				(0.071)	
R-squared	0.008		0.113		0.037		0.14	
Log-likelihood	-1.39E+04		-1.25E+04		-1.26E+04		-1.12E+04	
Number of observations	1,887,285		1,887,285		1,755,951		1,755,951	

Estimation result 2 (Manufacturing sector):

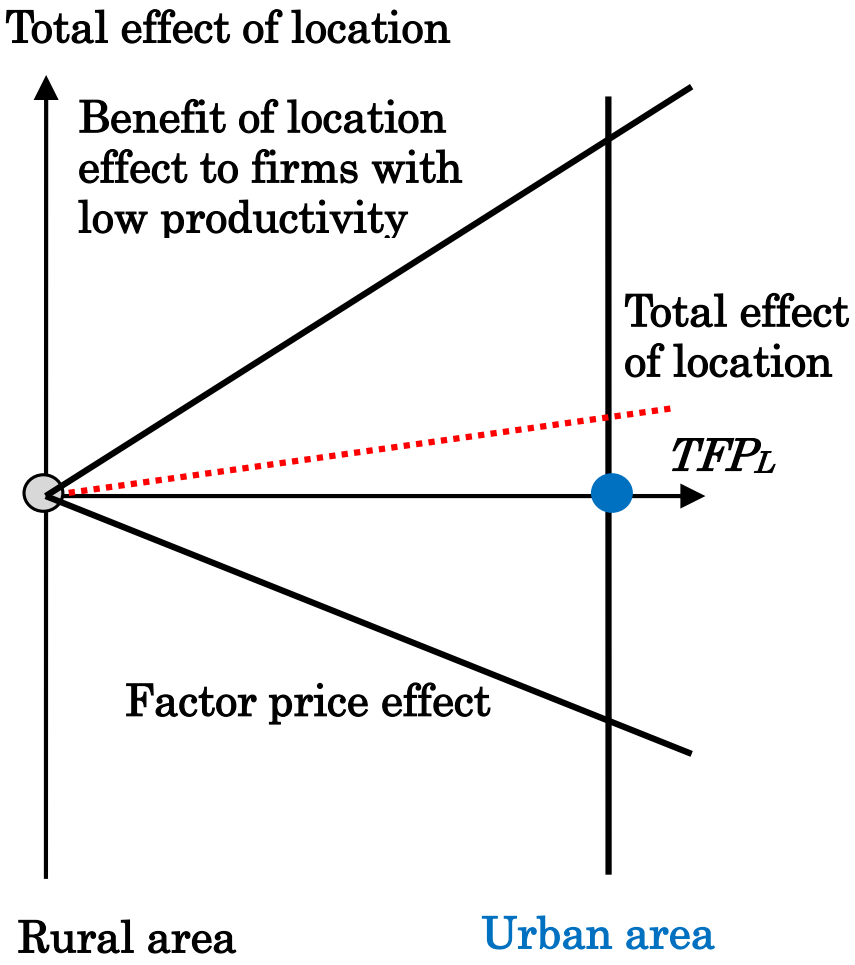
The estimated coefficients on the cross term of firm and location effects are negative and significant. This finding is consistent with the results of our analysis of the correlation between firm and location effects across factories.

LOCATION CHOICE MODEL 3

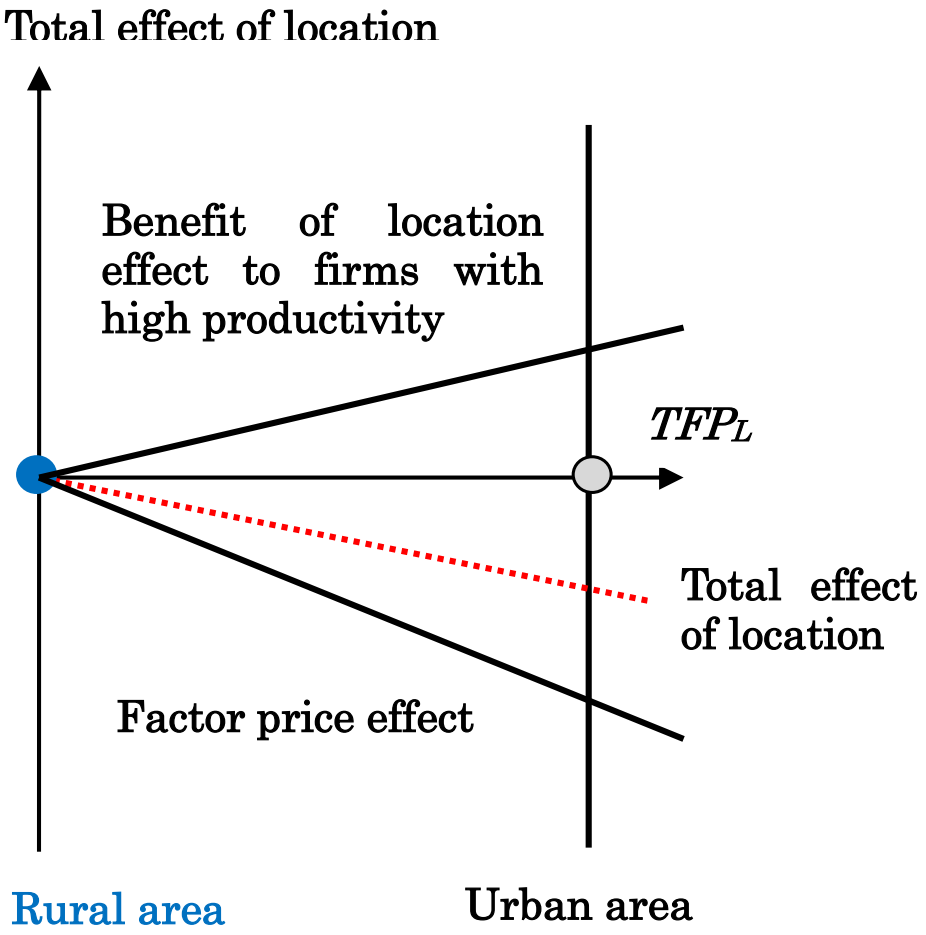
	(1)		(2)		(3)		(4)		(5)		(6)	
Location effect	3.41	***	3.42	***					3.66	***	3.67	***
	(0.236)		(0.238)						(0.255)		(0.259)	
Location effect*Firm effect	-1.49	***	-1.49	***					-1.66	***	-1.67	***
	(0.104)		(0.104)						(0.111)		(0.113)	
Indusrty agglomeration (t-1)					0.265	***	0.326	***	0.427	***	0.468	***
					(0.064)		(0.064)		(0.015)		(0.016)	
Indusrty agglomeration (t-1) •Firm effect					0.072	**	0.063	**				
					(0.028)		(0.028)					
Wage premium (t-1)	1.12	***			-0.635	***			-0.656	***		
	(0.153)				(0.183)				(0.183)			
ln(Land price of the city)(t-1)			0.166	***			-0.247	***			-0.251	***
			(0.025)				(0.030)				(0.030)	
ln(1+Number of factory of the same firm	3.62	***	3.61	***	3.63	***	3.64	***	3.62	***	3.63	***
in the same prefecture (t-1))	(0.069)		(0.069)		(0.071)		(0.071)		(0.071)		(0.071)	
R-squared	0.115		0.115		0.141		0.144		0.148		0.152	
Log-likelihood	-1.24E+04		-1.21E+04		-1.12E+04		-1.09E+04		-1.11E+04		-1.08E+04	
Number of observations	1,853,868		1,791,607		1,725,699		1,675,350		1,725,699		1,675,350	

Estimation result 3 (Manufacturing sector): we test that location effect and industry agglomeration captures pretty different aspects of the attraction of locations by adding the industry agglomeration to the location effects and its cross term with firm effects as an explanatory variable. Specifications 5 and 6 show that controlling such regional merits as location effects estimated above, industry agglomeration, and presence of factories of the same firm, factor prices such as wage premium and land price have negative effect on the choice. This result is consistent with our hypothesis.

Location decision of firms with low productivity



Location decision of firms with high productivity



CONCLUDING REMARKS

1)The estimation results show that both effects have a significant impact on the productivity level of a factory, and that the firm effects are more important than the location effects.

2)We also find a statistically significant negative correlation between firm effects and location effects, and investigate what causes this relationship.

3)One potential explanation is that more productive firms may tend to set up new factories in less productive locations such as rural areas, where factor prices such as land prices and wage rates are usually low, in order to benefit from low factor prices.

4)To examine this, we estimate a mixed logit model of location choice. The results indicate that more productive firms indeed tend to set up new factories in low-productivity locations with low land price and low wage rate, which is consistent with our hypothesis.

5)What are "location effects"?

6)We do not take account of division of labor within firms.