Agglomeration Economies in Japan: Technical Efficiency, Growth and Unemployment

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Technical Efficiency, Growth and Unemployment

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Abstract: This paper examines if the effects of agglomeration economies get manifested in technical efficiency and generate faster economic growth and higher (lower) levels of employment (unemployment). Using the prefecture level data for each of the two-digit groups of industries in Japan, the paper estimates region-specific technical efficiency index based on the stochastic frontier production function framework. The results of the factor analysis show that in most of the industry-groups (with a few exceptions) efficiency has a positive association with external scale variable(s). Though the relationship is not seen to be very strong, it would be equally erroneous to ignore the effect of agglomeration economies on efficiency. In the case of some of the light goods industries the agglomeration effect is relatively stronger. Further, economic growth varies positively with external scale variable(s) and unemployment rate tends to fall with respect to growth and concentration. All this tends to suggest that measures against industrial concentration may be counter-productive, particularly in the context of globalisation when countries are in dire need of raising productivity.

Keywords: agglomeration economies, technical efficiency
JEL classification: J60, L60, R12,

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1. Perspective

In the process of economic development not only industrialisation leads to urbanisation but also urbanisation has productivity-augmenting effects on industry (Mills, 1967; Henderson, 1986; Krugman, 1991; Fujita and Thisse, 2003; Kuchiki, 2005). The major links between concentration (of population and activities) on the one hand, and industrial productivity on the other include several factors such as complementary services that reduce cost of operation, the declining effective price of infrastructure (power, water supply, roads etc.), and backward and forward linkages among activities. An important mechanism through which concentration is said to impact positively on performance is perceived in terms of technical efficiency (Mitra, 1999). In other words, the benefits of agglomeration economies arising in large urban settlements tend to get manifested in firms' technical efficiency which is higher than that of firms located in medium sized and small towns[1]. This aspect of the agglomeration theory motivates us to examine if regions with higher concentration of population or industry also reveal higher technical efficiency in general.

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[1] Total factor productivity growth, in a dynamic sense, is equal to technological progress (regress) plus the change in technical efficiency. So at a particular point of time given the level of technology, it is the difference in technical efficiency that explains the difference in performance. Of course this is based on the assumption that once a technological advancement takes place in one region its dissemination occurs instantaneously. So at a particular point of time differences in performance are mainly determined by the extent to which one is able to utilise the available technology.

Empirical evidence on the existence of agglomeration economies has been somewhat mixed. Moomaw (1983), Segal (1976), Shukla (1984), and Sviekauskas (1975) observed that productivity is generally higher in larger cities. Carlino (1979) on the other hand noted that population scale had a negative effect on productivity reflecting diseconomies rather than economies of agglomeration. Henderson (1986; 1988) observed the significance of localisation economies which tend to peter out as a city expands, implying that there is a limit to the benefits of agglomerating similar activities. In the context of Japanese cities, Nakamura (1985) observed that light industries received more productive advantages from urbanisation economies than from localisation economies whereas in the case of heavy industries it was the reverse. The policy implications of these findings are important, particularly in the context of the spatial distribution of industry.

Fujita and Thisse (2003) argued further that agglomeration economies lead to higher growth because with the movement of the economy from dispersion to agglomeration, innovation follows a much faster pace. Though this seems to provide support to the trade-off between growth and spatial equity, the additional growth spurred by agglomeration may lead to a Pareto-dominant outcome: even firms which stay in the periphery and are not in the core, are better-off than under dispersion. Romer (1996) emphasising the role of market size argued based on historical experience that large markets create greater incentives to discover new ways to use resources. On the other hand, Jones (1995) noted that the growth rates in the major OECD countries do not seem to be proportional to the size of the labour force in those countries, rather are constant or declining. Futagami and Ohkusa (2003) demonstrated an inverted U-shape relationship between market size, measured in terms of population size, and growth rate. This means that both small and large economies grow sluggishly compared to the medium-sized economies. All this widens our hypothesis, suggesting that concentration, technical efficiency, and economic growth all three are in relationship.

Economic growth, even when it is accompanied by high degree of mechanisation, generates employment opportunities at least indirectly if not directly. The complementary relationship among activities and backward and forward linkages among sectors operate to allow the growth effect in one sector to spill-over to the rest in a particular region (Papola, 1981). As a result, though migration to regions with higher growth are possibly faster than regions with relatively lower growth, unemployment rates are expected to vary inversely with concentration, which forms an additional component of our hypothesis.

All these postulations have important policy implications, and hence warrant a thorough empirical investigation. We pursue this framework to analyse the patterns at the prefecture level of the Japanese economy with a belief that if this holds in a relatively small (and culturally more homogeneous) but highly advanced economy that is characterised by rapid technological progress and faster levels of communication channels operating across regions, then in a country at a lower level of development with much wider socio-cultural, geographic and economic variations and with not-so-advanced channels for technology-dissemination, its applicability would be much stronger. The organisation of the paper is as follows. The next section refers to regional diversities in certain important indicators at the prefecture level in Japan and also refers to the regional distribution of industrialisation process. Section 3 focuses on the methodology. The empirical results on estimation of efficiency indices for each of the two-digit industry groups and their relationship with other indicators of agglomeration, growth and wellbeing are presented in section 4 and the major findings are summarized in section 5. The data base of the study is drawn from the Census of Manufactures, 2005, Annual Report on the Labour Force Survey, 2004 and Japan Statistical Yearbook, 2005.

2. Regional Diversity: Broad Patterns

Notwithstanding the small size of the country the regional diversities in Japan are sizeable. Table 1 gives the distribution of manufacturing employment, gross value added and value of tangible fixed assets at the end of the year taken as a proxy for capital across different prefectures for the year 2003. The manufacturing sector in this study includes establishments with 30 or more employees. It is evident from Table 1 that in terms of manufacturing employment while only a handful of prefectures (Saitama, Kanagawa, Shizuoka, Aichi, Osaka and Hyogo) have relatively high shares, i.e. at least 5.0 per cent or more, Kochi and Okinawa on the other extreme correspond to a very low share of 0.2 to 0.3 per cent in the total. Similarly in terms of gross value added as well, the unequal distribution across regions is quite prominent. The same prefectures as noted in the case of employment are also seen with relatively higher percentage shares in terms of gross value added. Also, the distribution of total capital stock by and large conforms to this pattern with a slight variation: Ibaraki and Chiba appear in the list of relatively high shares instead of Saitama, while the other five are the same. In fact, the correlation coefficients between each of the pairs of the three percentage shares – employment, value added and capital - are above 0.95[2].

Table 1: Distribution of Employment, Gross Value Added and Capital across Prefectures in 2003 (%)

Prefecture		Employment	Gross Value Added	Capital
1	Hokkaido	2.129	1.594	2.054
2	Aomori	0.787	0.373	1.203
3	Iwate	1.291	0.673	0.819
4	Miyagi	1.655	1.096	1.242
5	Akita	0.940	0.466	0.495
6	Yamagata	1.458	0.860	0.869
7	Fukushima	2.329	2.099	2.144
8	Ibaraki	3.530	3.903	4.571
9	Tochigi	2.696	3.000	2.774
10	Gumma	2.651	2.686	2.365
11	Saitama	5.011	4.580	4.286
12	Chiba	2.799	3.631	4.964
13	Tokyo	3.848	3.856	2.796
14	Kanagawa	5.817	6.907	6.667
15	Niigata	2.416	1.783	2.030
16	Toyama	1.641	1.655	1.525
17	Ishikawa	1.077	0.813	0.763
18	Fukui	0.879	0.670	0.760
19	Yamanashi	0.908	0.765	0.947
20	Nagano	2.649	2.056	1.934
21	Gifu	2.238	1.794	1.716
22	Shizuoka	5.492	6.268	5.193
23	Aichi	10.294	11.811	10.144
24	Mie	2.434	2.906	3.050
25	Shiga	2.017	2.690	2.186

2 Cor (EMP,GVA) = 0.985, Cor (EMP, CAP) = 0.960 and Cor (CAP, GVA) = 0.980.

26	Kyoto	1.816	1.964	1.594
27	Osaka	5.473	5.717	5.137
28	Hyogo	4.599	4.763	5.291
29	Nara	0.796	0.752	0.675
30	Wakayama	0.550	0.887	0.916
31	Tottori	0.519	0.321	0.351
32	Shimane	0.527	0.314	0.333
33	Okayama	1.932	2.087	2.257
34	Hiroshima	2.587	2.824	3.332
35	Yamaguchi	1.322	1.916	2.079
36	Tokushima	0.585	0.789	0.641
37	Kagawa	0.800	0.637	0.773
38	Ehime	1.026	1.007	1.503
39	Kochi	0.279	0.223	0.214
40	Fukuoka	2.756	2.660	2.772
41	Saga	0.761	0.583	0.567
42	Nagasaki	0.697	0.394	0.611
43	Kumamoto	1.252	0.933	1.104
44	Oita	0.864	1.137	1.140
45	Miyazaki	0.740	0.435	0.422
46	Kagoshima	0.930	0.607	0.593
47	Okinawa	0.206	0.114	0.197
	Total	100.000	100.000	100.000

Source: *Census of Manufactures 2003, Report by Industry*, (2005), Research and Statistics Department, Economics and Industrial Policy Bureau, Ministry of Economy, Trade and Industry, Japan.

The composition of the manufacturing sector in Japan, as shown in Table 2, reveals wide variations. In terms of employment, manufacture of food (9), general machinery (26) and transport equipment (30) each accounted for more than 10 per cent in 2003. On the other hand, beverages, tobacco and feed (10), textile mill products (11), lumber and wood products (13), furniture and fixtures (14) and miscellaneous (32) each comprised only around one per cent of the total employment. The distribution of gross value added across different industry divisions also shows that food (9), chemical and allied products (17), general machinery (26) and transport equipment (30) are on the top. There is a strong correlation between the employment and gross value added shares (0.84), and also between capital and gross value added shares (0.93) across industries though the correlation between employment and capital shares is relatively small (0.77).

Table 2: Composition of Manufacturing Sector in 2003 (%)

	Industry	Employment	Gross Value Added	Capital
9	Food	14.11	8.58	8.16
10	Beverages, Tobacco and Feed	1.11	3.28	3.05
11	Textile Mill products	1.35	0.80	1.08
12	Apparel and other finished products	2.27	0.72	0.54
13	Lumber and Wood products	0.82	0.56	0.61
14	Furniture and Fixtures	0.99	0.65	0.69
15	Pulp, Paper and Paper products	2.56	2.66	4.86
16	Printing and Allied industries	3.45	2.69	2.67
17	Chemical and allied products	5.36	13.05	11.09
19	Plastic products	4.80	3.78	4.03
20	Rubber products	1.56	1.41	1.14
22	Ceramic, Stone and Clay products	2.84	2.81	3.86
23	Iron and Steel	2.91	4.69	9.04
24	Non-Ferrous Metals and products	1.84	1.63	3.67
25	Fabricated metal products	5.80	4.47	4.93
26	General Machinery	11.20	9.88	8.55
27	Electrical Machinery	8.01	6.94	4.86
28	Information Electronics Equipment	3.59	3.68	1.79
29	Electronic Parts and Devices	7.92	7.43	7.51
30	Transportation Equipment	13.56	16.65	13.20
31	Precision Instruments	2.00	1.60	1.06
32	Miscellaneous	1.46	1.34	1.07
	Total	99.51	99.29	97.45

Note: Total is not 100 per cent as two industry divisions 18 and 21 are excluded for not being present in a large number of prefectures. The precise industrial classification table is attached as Appendix.

Source: Same as Table 1.

Like the manufacturing value added or employment, several other variables like per capita income, population density, unemployment rate, the proportion of total manufacturing employment to the total workforce, also show considerable variations across regions (Table 3). The unemployment rate in Okinawa, for example, is as high as 7.8 per cent accompanied by the lowest per capita income (2,057 thousand Yen) and the lowest percentage of manufacturing employment (5.22 per cent). On the other hand, Tokyo with the highest per capita income of 4,219 thousand Yen is accompanied by a higher proportion of manufacturing employment (14.76 per cent), if not highest, and lower unemployment rate (5.0 per cent), though not lowest among all. All this tends to form the basis of our argument that such variations can possibly be explained, at least partly, in terms of the existence of agglomeration economies. The correlation coefficient between the rate of unemployment and the per capita gross domestic product is -0.30 and also the correlation between the proportion of total manufacturing employment to total workforce (a proxy for agglomeration variable) and the unemployment rate is around -0.58 (see Figure 1). Further, the percentage share of manufacturing employment in the total workforce and per capita income show a reasonable degree of association between them (0.50). The alternative index of agglomeration variable conceptualised in terms of population density bears even a stronger association with per capita income (0.64, see Figure 2). In other words, per capita income taken as a proxy for growth index seems to be positively associated with agglomeration variable, and growth tends to raise employment for which the rate of unemployment rate falls with a rise in per capita income.

In section 4 we turn to the estimation of efficiency index for each of the two-digit groups of industries and examine if technical efficiency is the major link between agglomeration variable and growth. In other words, we try to assess if agglomeration economies manifest themselves in higher technical efficiency, which in turn leads to higher economic growth and lower unemployment rates.

Table 3: Regional Variations in Certain Indicators

Prefecture		Unemployment Rate (%) In 2003	Population Density (per km sq) in 2003	Per Capita Income (in 1000Y) in 2001	Share of Manufacturing Employment in Total Workers (%) in 2000
1	Hokkaido	6.5	73	2782	9.41
2	Aomori	7.0	154	2359	11.93
3	Iwate	5.4	93	2460	17.33
4	Miyagi	6.3	325	2589	15.09
5	Akita	5.5	102	2402	17.86
6	Yamagata	4.3	133	2446	23.17
7	Fukushima	5.3	154	2748	22.81
8	Ibaraki	5.0	490	2951	23.74
9	Tochigi	4.9	313	3135	26.59
10	Gumma	4.8	318	2914	26.92
11	Saitama	5.5	1827	2826	21.26
12	Chiba	5.0	1149	3143	15.19
13	Tokyo	5.0	5517	4219	14.76
14	Kanagawa	4.8	3515	3051	18.66
15	Niigata	4.6	197	2759	21.56
16	Toyama	3.8	264	2916	26.42

17	Ishikawa	3.8	282	2950	21.50
18	Fukui	4.1	198	2903	25.23
19	Yamanashi	4.4	199	2635	23.36
20	Nagano	3.9	163	2824	24.50
21	Gifu	4.0	199	2809	27.93
22	Shizuoka	4.0	484	3149	28.27
23	Aichi	4.0	1366	3481	27.96
24	Mie	4.7	322	2853	26.02
25	Shiga	4.5	334	3156	30.34
26	Kyoto	6.0	573	2768	20.55
27	Osaka	7.6	4652	3096	20.63
28	Hyogo	6.5	661	2657	21.09
29	Nara	5.2	391	2703	21.04
30	Wakayama	5.2	226	2396	16.63
31	Tottori	4.3	175	2524	18.18
32	Shimane	3.3	114	2478	15.90
33	Okayama	4.4	274	2791	21.86
34	Hiroshima	4.6	340	2904	19.47
35	Yamaguchi	5.1	250	2801	17.80
36	Tokushima	6.4	199	2659	17.39
37	Kagawa	4.4	545	2746	18.79
38	Ehime	4.7	263	2466	17.89
39	Kochi	5.0	115	2318	10.15
40	Fukuoka	6.8	1009	2529	13.69
41	Saga	4.9	359	2453	16.47
42	Nagasaki	5.3	371	2336	11.82
43	Kumamoto	5.5	251	2522	13.87
44	Oita	4.7	193	2637	14.41
45	Miyazaki	5.8	151	2440	13.58
46	Kagoshima	5.6	194	2285	12.67
47	Okinawa	7.8	580	2057	5.22
	Total	5.3	340	2971	19.40

Source: *Statistical Year Book 2005*, (2005) Statistical Bureau/Statistical Research and Training Institute, Ministry of Public Management, Home Affairs, Post and Telecommunications, Japan and *Annual Report on the Labour Force Survey 2004*, (2005) Statistics Bureau, Ministry of Internal Affairs and Communications, Japan.

Figure 1: Unemployment Rate and the Proportion of Manufacturing Employment to Total Work force

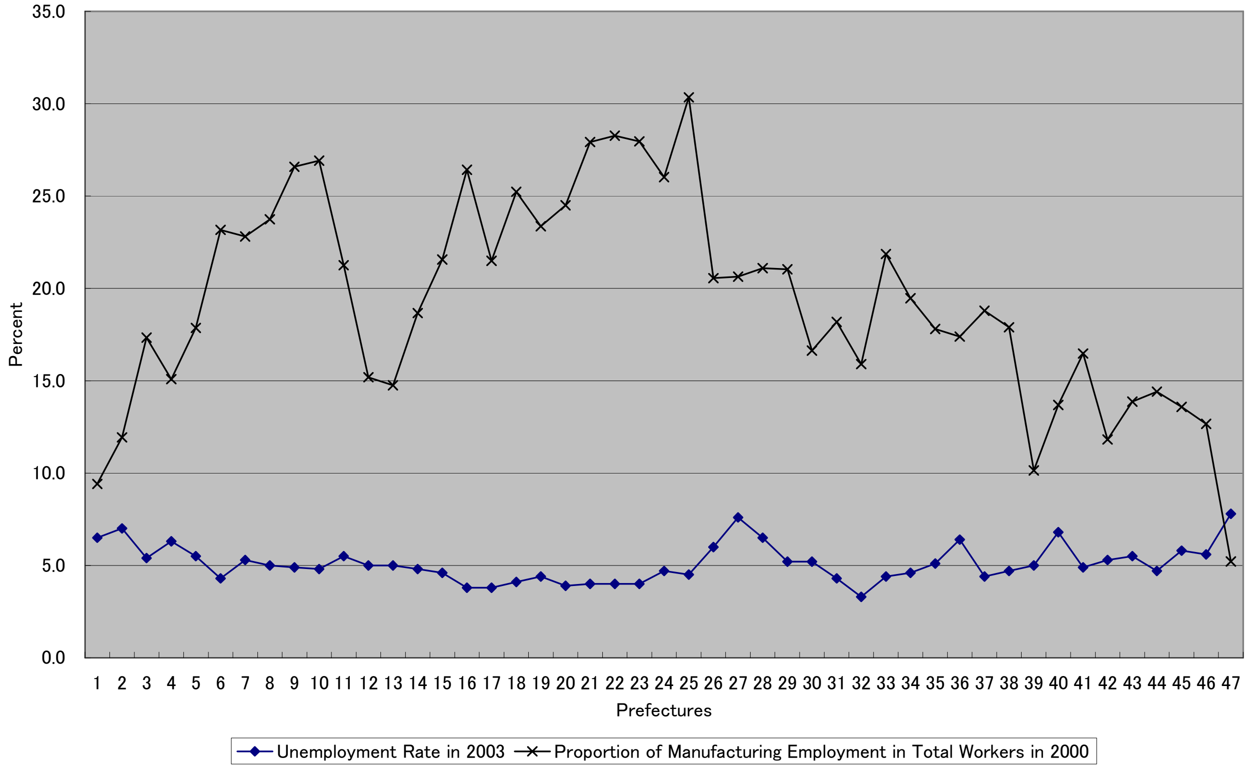
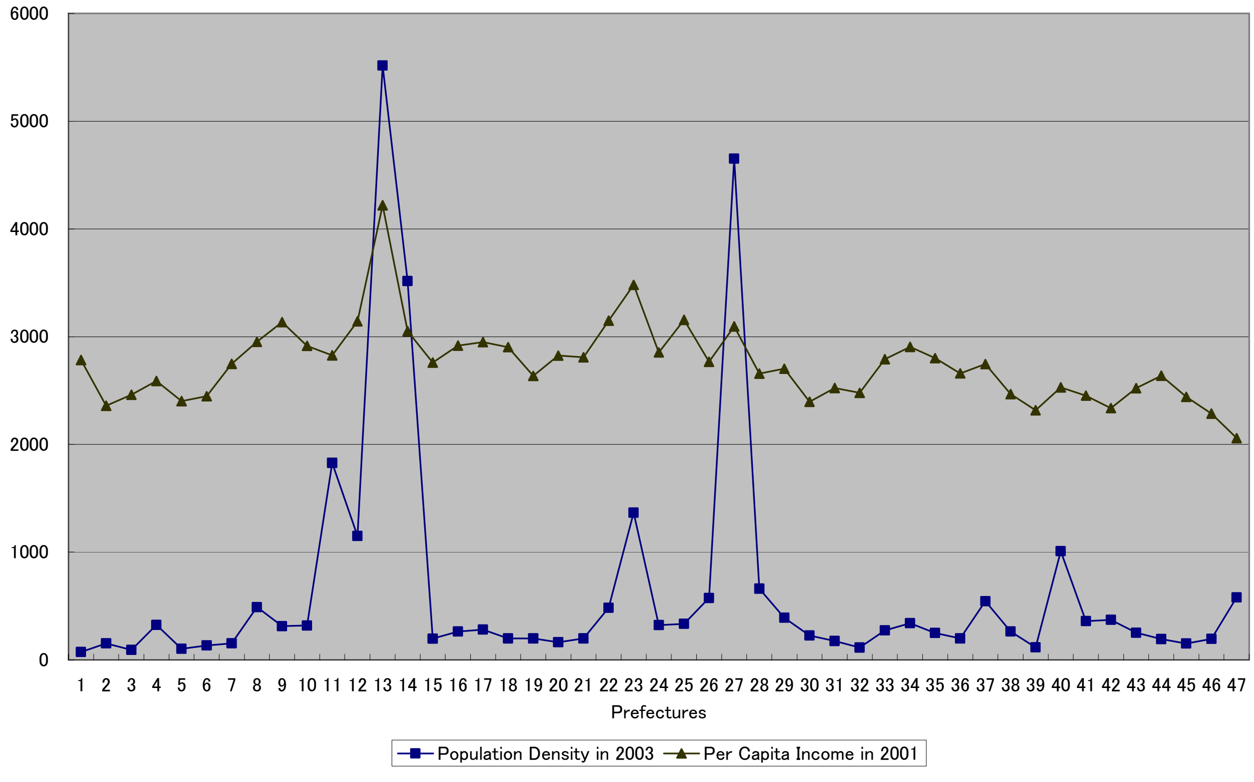


Figure 2: Population Density and Per Capita Income



3. Methodology

The significance of agglomeration economies and their beneficial effects in terms of higher growth and a lower incidence of unemployment are examined at two steps. First, using the concept of frontier production function, we estimate technical efficiency for each of the two digit industry-groups of the manufacturing sector. The stochastic frontier production function is defined by

$$Y_{pi} = F(K_{pi}, L_{pi}) \exp(V_{pi} - U_{pi})$$

where, p and i stand for prefecture and industry respectively and Y is value added, K, capital and L, labour. U represents non-negative random variable affiliated with region specific factors that do not allow p th region to attain the maximum efficiency of production and V is random error term. Representing frontier output as Y^*, TE_{pi}, the technical efficiency of the p th prefecture for a given industry i, is defined as,

$$TE_{pi} = Y_{pi} / Y_{pi}^* = F(K_{pi}, L_{pi}) \exp(V_{pi} - U_{pi}) / F(K_{pi}, L_{pi}) \exp(V_{pi}) = \exp(-U_{pi})$$

In the second step, we examine the association between the technical efficiency of each of the industry groups on the one hand and on the other, per capita income, unemployment rate and the agglomeration variable conceptualized in terms of two alternative indices, namely the proportion of manufacturing employment and population density as mentioned above. This is pursued in terms of factor analysis because the regression framework requires clear cut causality connections and secondly, the variables of our concern cannot be tackled in a single equation model. In other words, it requires a system of equations for a group of jointly determined endogenous variables keeping in view the possibility of simultaneity that may exist among the variables. Since empirical estimation of such a model requires inclusion of several variables for the equations to be identified, we prefer to base our estimation on factor analysis. A simple correlation analysis on the other hand takes only two variables at a time, while factor analysis enables to observe the association among a group of variables at a time, though the basic input for this analysis is the correlation matrix (Harman, 1967). The significant factors are identified on the basis of the magnitude of the eigenvalue, i.e., if the eigenvalue is greater than one then the factor is treated as significant. The factor loadings from the rotated factor matrix (rotated by varimax technique) are considered for interpretation as the unrotated factors are not statistically independent of each other.

4. Empirical Results

For each of the industry groups Cobb-Douglas production function in terms of value added has been estimated in a stochastic frontier framework by applying the maximum likelihood method (Table 4). Following Aigner, Lovell and Schmidt (1977) the maximum likelihood estimate of the parameters are obtained in terms of parameterisation,

$$\tilde{\sigma} = \sqrt{\sigma_v^2 + \sigma^2} \textit{ and } \lambda = \sigma / \sigma_v$$

where σ is the standard deviation of the N(0, σ^2) distribution required for the non-negative errors(U), and σ_v is the standard deviation of the symmetric errors (V) (Battese, 1991). Since we have used purely cross-sectional data, and not panel data, specific distributional assumptions about the one-sided component of the disturbance term has to be made in order to obtain estimates of efficiency for individual prefectures (see Bauer, 1990). In this case we assume that the errors representing the efficiency (inefficiency) follow half-normal distribution. When σ_v is the standard deviation of the symmetric errors, σ is not the standard deviation of the non-negative errors when they follow half-normal distribution. The variance of the non-negative errors when they follow half-normal distribution is given by $\left[(\pi/2)-1\right]\sigma^2$.

The results of the frontier production function for each of the two-digit industry groups are presented in Table 4. The logarithm transform of gross value added (lnGVA) has been regressed on logarithm transform of employment (lnEMP) and capital (lnCAP). The coefficients representing the elasticity of value added with respect to employment and that with respect to capital are both positive for all the industries, suggesting that the marginal productivity of labour and capital are positive too[3]. Both in terms of t-ratios corresponding to the coefficients and the chi-square values representing the overall goodness of fit of the equations, the results are satisfactory. Except is a few cases, t-ratios are mostly significant. Following Jondrow et al. (1982) the non-negative errors are predicted by their conditional expectation given the value of the observable random variable, $e \cong V_p - U_p$, i.e., U_p is computed by $E[(U_i \left| V_i\right.) - U_i]$. Once the prefecture specific efficiency index for each industry, e^{-Up}, is generated, in step 2 we examine its relationship with other variables mentioned above.

[3] The Cobb-Douglas form being highly flexible the monotonic and convexity conditions usually hold good.

Table 4: Stochastic Frontier Production Function (Maximum Likelihood Estimates)

Dependent Variable: lnGVA

	9	10	11	12	13	14	15	16	17	19	20
lnEMP	0.31	0.30	0.88	0.47	0.81	0.37	0.67	0.81	1.02	0.35	1.11
	(3.11)*	(1.31)	(8.66)*	(7.43)*	(5.31)*	(2.71)*	(8.77)*	(7.39)*	(4.98)*	(2.27)*	(5.77)*
lnCAP	0.79	0.68	0.23	0.55	0.29	0.64	0.46	0.30	0.24	0.71	0.15
	(9.20)*	(4.45)*	(2.45)*	(8.94)*	(2.37)*	(5.64)*	(7.57)*	(3.21)*	(1.38)	(5.55)*	(1.04)
CONS	-0.42	1.42	0.73	0.82	0.84	0.77	0.40	0.81	0.32	0.43	0.09
	(-0.73)	(1.21)	(1.00)	(1.19)	(1.31)	(1.12)	(1.20)	(2.32)*	(0.38)	(1.08)	(0.14)
lnsig2v	-3.69	-0.97	-2.55	-2.85	-2.31	-2.34	-3.87	-3.25	-1.47	-3.38	-2.00
lnsig2u	-8.77	-8.43	-9.57	-11.72	-10.48	-9.95	-2.35	-12.60	-9.31	-2.81	-10.57
Obs	47	44	41	45	43	40	47	47	45	47	37
Chi2	1821.2	91.6	674.9	265.5	348.4	474.0	980.5	1736.8	510.6	1036.5	469.2

	22	23	24	25	26	27	28	29	30	31	32
lnEMP	0.62	0.95	0.84	0.46	0.38	0.94	0.94	0.52	0.64	0.27	0.83
	(5.21)*	(5.03)*	(3.33)*	(3.64)*	(1.77)**	(9.48)*	(4.44)*	(a)*	(4.22)*	(1.44)	(5.71)*
lnCAP	0.53	0.27	0.07	0.59	0.66	0.29	0.27	0.20	0.44	0.76	0.34
	(5.25)*	(2.00)**	(0.35)	(5.55)*	(3.53)*	(3.15)*	(1.66)	(b)*	(3.21)*	(4.62)*	(3.33)*
CONS	0.06	0.62	3.42	0.55	0.68	-0.26	0.27	5.43	1.21	0.77	0.40
	(0.11)	(1.39)	(4.07)*	(1.56)	(1.20)	(-0.48)	(0.28)	(c)*	(3.14)*	(1.17)	(0.64)
lnsig2v	-2.34	-2.28	-1.80	-3.43	-2.77	-2.23	-1.41	-34.09	-2.55	-2.00	-1.80
lnsig2u	-2.73	-1.33	-0.82	-12.41	-11.36	-10.97	-10.06	0.03	-1.72	-11.64	-11.07
Obs	47	43	38	47	46	47	39	46.00	45	37	33
Chi2	448.9	529.4	83.7	1953.4	871.9	824.9	355.3	1.1E+10	942.1	475.0	289.6

Note: lnGVA, lnEMP and lnCAP are logarithm transformation of gross value added, employment and capital respectively. CONS is the intercept. Figures in parentheses are t-ratios. * indicates significance at 5 per cent level and ** at 10 percent level. Chi-square values with two degrees of freedom are highly significant for each of the equations. (a)Standard Error 0.00002, (b) Standard Error 0.00002, (c) Standard Error 0.00007. Two industry divisions 18 and 21 are excluded for not being present in a large number of prefectures .

In factor analysis, the basic assumption is that each variable can be expressed in terms of certain unobservable factors, and the coefficients of these factors are called factor loadings. So the primary objective is to discern a prominent mapping pattern, if any, between factors and variables. This is of course done only in relation to the dominant or significant factors. In other words we try to identify the variables which are largely explained by the dominant factor(s).

Two separate sets of factor analysis have been carried out. One considers the proportion of manufacturing employment to total workforce (MT) as a proxy for agglomeration variable and the other takes population density (POPDEN) as a measure of the same variable. Efficiency, per capita income (PCI) and unemployment rate (UMP) are the common variables in both the sets. Except for the industry group 10, all others seem to have only one dominant factor with an eigenvalue greater than 1.

The results presented in Table 5 bear certain interesting features. For most of the industry groups at least one of the two agglomeration specific variables seems to be having a positive association with efficiency. Variable(s) representing agglomeration economies seem to correspond to high factor loadings, though corresponding to efficiency the factor 1 does not necessarily show high factor loadings. However, by taking 0.10 as the cut-off level it may be concluded that efficiency is at least moderately related to agglomeration economies in most of the cases except the four industry groups (12, 15, 23, and 32). Among the industry groups, showing a positive relationship with agglomeration variable(s), food (9), beverages (10), textiles (11), lumber and wood (13), furniture (14), non-ferrous metals and products (24) and electronic parts and devices (29) are accompanied by a relatively high factor loading (at least 0.25) corresponding to technical efficiency. Since most of these groups are light goods industries except 24 and 29, it may be safe to suggest that agglomeration effects are relatively stronger in such industries vis-à-vis heavy industries, though in the latter group of industries also agglomeration effect works.

The factor loading corresponding to per capita income is also on the high side with positive sign for most of the industry groups. Hence, the agglomeration economies are seen to be accompanied by higher levels of growth as well, and the mechanism of agglomeration economies impacting on growth is seen at least partly in terms of technical efficiency. In a dynamic sense this would mean that agglomeration economies lead to higher economic growth by raising the total factor productivity growth. Also, the unemployment rate is seen to be accompanied by a high factor loading (except for the industry group 11) at least when the agglomeration variable is gauged in terms of the percentage of manufacturing employment in total work force. This tends to support the view that higher growth also generates employment opportunities and hence, large urban centres are characterised by lower unemployment rates. However, the fact that efficiency index does not correspond to a high factor loading implies the existence of many other mechanisms through which agglomeration economies generate higher growth. Given the fact that in the existing literature empirical evidence on the existence of agglomeration economies has been somewhat mixed, these findings have important implications both from analytical and policy point of view.

Table 5: Results from Factor Analysis

	9	10	11	12	13	14	15	16	17	19	20
Efficiency	0.3668	0.0880	0.6353	0.0675	0.2706	0.0623	-0.1115	0.1848	0.2318	0.0861	0.1093
MT	0.7899	0.7398	0.3076	0.7360	0.6327	0.6226	0.7601	0.7691	0.7722	0.7646	0.7105
PCI	0.5256	0.4582	0.6606	0.5119	0.3192	0.2241	0.5481	0.5430	0.5314	0.5394	0.3130
UMP	-0.6281	-0.6932	0.0689	-0.5329	-0.6112	-0.5663	-0.6421	-0.6345	-0.6486	-0.6398	-0.6745
Eigenvalue	1.4847	1.4327	1.1675	1.1145	1.3344	0.9252	1.3055	1.3240	1.3548	1.3008	1.2780

	9	10	11	12	13	14	15	16	17	19	20
Efficiency	0.1981	0.2532	0.5886	0.0508	0.4152	0.3131	-0.0292	0.0085	-0.0045	0.1061	0.2288
POPDEN	0.7942	0.7898	0.7738	0.7853	0.8562	0.7906	0.8017	0.7873	0.7975	0.7850	0.8165
PCI	0.7732	0.8117	0.8291	0.7950	0.7485	0.7995	0.7895	0.7810	0.7841	0.7840	0.8309
UME	-0.0083	-0.0467	0.0302	0.0004	0.0601	0.0867	-0.0200	-0.0240	-0.0256	-0.0260	0.0008
Eigenvalue	1.2933	1.3901	1.7127	1.2530	1.5452	1.3703	1.2762	1.2376	1.2627	1.2484	1.4449

	22	23	24	25	26	27	28	29	30	31	32
Efficiency	0.1183	-0.0864	0.4087	0.2429	0.0953	0.2274	0.1639	0.0586	-0.0591	0.2361	0.0607
MT	0.7526	0.7561	0.6898	0.7445	0.7152	0.7802	0.6900	0.6599	0.7153	0.7207	0.7412
PCI	0.5202	0.5274	0.3522	0.5664	0.4893	0.5344	0.4138	0.3708	0.4617	0.4459	0.5181
UMP	-0.6453	-0.6219	-0.7290	-0.6016	-0.5646	-0.6340	-0.6004	-0.6051	-0.5745	-0.6734	-0.5880
Eigenvalue	1.3170	1.2457	1.2984	1.4053	1.0800	1.3709	1.0905	1.1599	1.0739	1.2278	1.1682

	22	23	24	25	26	27	28	29	30	31	32
Efficiency	0.1117	-0.1308	0.0230	-0.0410	0.0585	0.0703	0.0361	0.3053	0.1726	-0.1253	-0.0394
POPDEN	0.7857	0.7873	0.8109	0.7843	0.7911	0.7881	0.8034	0.7654	0.7925	0.8256	0.8434
PCI	0.7946	0.7832	0.8075	0.7864	0.7879	0.7869	0.8130	0.8225	0.7924	0.8152	0.8447
UMP	-0.0282	-0.0226	0.0106	-0.0341	0.0124	-0.0236	0.0220	-0.0124	0.0159	-0.0258	0.0101
Eigenvalue	1.2725	1.2523	1.3102	1.2390	1.2505	1.2550	1.3109	1.3684	1.2901	1.3632	1.4279

5. Conclusion

This paper addresses itself to the issue of agglomeration economies and its effect on economic growth and unemployment. The major links between external scale economies and growth are perceived in terms of technical efficiency, and higher growth is taken to reduce the unemployment rate. Based on the stochastic frontier production function framework the technical efficiency index for each of the prefectures is estimated for most of the two-digit industry groups. In the second stage the relationship among the efficiency index corresponding to each industry, agglomeration specific variable(s), growth indicator (per capita income) and welfare indicator (the unemployment rate) is examined in terms of factor analysis. For the external scale variables two alternative indices are selected: one is population density and the other is percentage of total manufacturing employment in total work force.

The empirical results are suggestive of the positive effect of agglomeration economies on efficiency, though efficiency does not take high factor loadings in a large majority of the cases. However, it would be misleading to ignore the agglomeration effects either. In some of the light goods industries particularly the effect is relatively stronger. The study also verifies that agglomeration effects are seen in terms of higher growth indicator and lower unemployment rates. It may, therefore, be concluded that technical efficiency is only one of the various mechanisms in terms of which agglomeration effects translate themselves into higher economic growth. Further research is needed to identify some of those channels. The policy implication of the study is that concentration can be effective in raising higher productivity and growth, and dispersal policy can prove to be counter-productive. This has a lesson for developing economies, which are in strong need of raising productivity in the face of globalisation and rising competition. However, to what extent these countries can allow interspatial-inequality to grow so as to fasten economic growth is a critical question, which cannot be answered in the light of this paper.

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Appendix

Industrial Classification Table (Manufacturing)

Number	Industry
9	Manufacture of Food
10	Manufacture of Beverages, Tobacco and Feed
11	Manufacture of Textile Mill products,
	except Apparel and other finished products made from Fabrics and similar materials
12	Manufacture of Apparel and other finished products made from Fabrics and similar materials
13	Manufacture of Lumber and Wood products, except Furniture
14	Manufacture of Furniture and Fixtures
15	Manufacture of Pulp, Paper and Paper products
16	Printing and Allied industries
17	Manufacture of Chemical and Allied products
18	Manufacture of Petroleum and Coal products
19	Manufacture of Plastic products, except otherwise classified
20	Manufacture of Rubber products
21	Manufacture of Leather, Tanning, Leather products and Fur Skins
22	Manufacture of Ceramic, Stone and Clay products
23	Manufacture of Iron and Steel
24	Manufacture of non-Ferrous Metals and products
25	Manufacture of Fabricated Metal products
26	Manufacture of General Machinery
27	Manufacture of Electrical Machinery, Equipment and Supplies
28	Manufacture of Information and Communication Electronics Equipment
29	Manufacture of Electronic Parts and Devices
30	Manufacture of Transportation Equipment
31	Manufacture of Precision Instruments and Machinery
32	Miscellaneous Manufacturing Industries

Source: *Census of Manufactures 2003*, *Report by Industry*, (2005), Research and Statistics Department, Economics and Industrial Policy Bureau, Ministry of Economy, Trade and Industry, Japan.