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Productivity distribution, firm heterogeneity, and agglomeration:
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Abstract

This paper empirically examines how productivity distributions of firms vary across regions based on Japan's manufacturing census data. We find that firm productivity is distributed with wide dispersions, especially in core regions. Our firm-level estimates demonstrate that the productivity distribution of firms tends to be noticeably left-skewed, deviating from the normal distribution, especially in regions with weak market potential but also in agglomerated or urbanized regions. These findings suggest that agglomeration economies are likely to accommodate heterogeneous firms that co-exist in the same region.

Keywords: agglomeration; productivity; gamma distribution; heterogeneity; firm-level data
JEL Classifications: L11; R12

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1. Introduction

Productivity differs across firms subject to a certain distribution. While previous literature has already established that the average productivity in big cities and agglomerated areas tends to be high,[1] little is known about how the firm productivity distribution is affected by geographical factors. This paper empirically examines, based on firm-level manufacturing census data, how higher moments (skewness and dispersion) of the productivity distribution across firms vary depending on the level of agglomeration.

Firms are tremendously heterogeneous in productivity even within the same region.[2] In a notable study on the firm productivity dispersion, Syverson (2004a) argues that larger local demand leads to a productivity distribution truncated from below due to intensified competition, and finds empirical evidence consistent with this prediction in the case of the ready-made concrete industry. However, factors other than intense competition are likely to affect the shape of productivity distributions. Among them, the agglomeration effect and Marshallian externality should be critical in considering economic geography. If these effects dominate the competition effect, firms should distribute over wider ranges of productivity in agglomerated regions, by accommodating unproductive firms to survive in the regions. Agglomeration fosters more varieties of products as well as wider ranges of firm productivity. In particular, many small-sized suppliers with relatively low productivity may operate in close proximity to a large, productive final assembler by providing inputs tailored to complicated assembler's requirements, probably facilitated by face-to-face contacts and local knowledge spillovers. Larger local demand may also allow heterogeneous firms to survive in the same region by supporting wider varieties of product differentiation. In other words, agglomeration should allow wider ranges of

1 See Rosenthal and Strange (2004) and Melo et al. (2009) as useful surveys of previous work.
2 This paper focuses on the firm side, but heterogeneity is also an important issue on the worker side. Using French data, Combe et al. (2008) investigate spatial selection in heterogeneous workers.

heterogeneous firms through positive externalities experienced in the world of many differentiated products as in advanced economies of our age. In the New Economic Geography (NEG) models, Okubo, Picard and Thisse (2010) formalize the spatial selection of heterogeneous firms in the trade-off between the market proximity versus the competition intensification, and show that high-productivity firms and low-productivity firms can co-exist within agglomerated regions. The current paper empirically investigates this theoretical prediction based on micro data.

In a different context, Cabral and Mata (2003), using Portuguese manufacturing census data, report that the firm size distribution is substantially right-skewed and becomes more proximate to a log-normal distribution as firms get older. Our paper is a spatial parallel to Cabral and Mata (2003) in that both estimate higher moments of the distribution of firms to examine its relation to competition.

This paper examines the productivity distribution of firms across regions. We empirically investigate the shape of productivity distributions based on firm-level data derived from Japan's manufacturing census. All firms with no less than five employees in all manufacturing industries across all regions in Japan are included in our sample of six consecutive waves of censuses. To preview the principal results, the productivity of firms tends to be distributed over relatively wide ranges, obviously deviating from the normal distribution, especially in core regions. By linking the estimated parameters of a gamma distribution with economic geography variables, we find that the productivity distribution tends to be less left-skewed (closer to the normal distribution) in regions with stronger market potential. The deviation from the normal distribution is sustained in agglomerated or urbanized regions, suggesting the important role of the positive externality in shaping the distribution of productivity across firms.

The rest of this paper is organized as follows. Section 2 briefly reviews related theoretical predictions. Section 3 describes the data. Section 4 reports our empirical results on the distributions of firm-level productivity and relates the parameter estimates to economic geography. Section 5 adds concluding comments.

2. Theoretical predictions

This section briefly reviews the recent theoretical literature on firm heterogeneity in economic geography. Among them, two papers are especially relevant for our purpose. First, Baldwin and Okubo (2006) show that, in geographical sorting of firms, high-productivity firms are more profitable and footloose and thus locate in large and competitive markets. Their model predicts that the relocation of productive firms leads to the high average productivity in agglomerated regions. This average productivity gap shown by Baldwin and Okubo (2006) is observationally in line with the empirical results by Syverson (2004a), though the latter emphasizes intensified competition in larger markets. We must, however, note that Baldwin and Okubo (2006) also indicate the co-agglomeration of firms with different productivity levels in agglomerated regions, as low-productivity firms remain dispersed across locations in their model.

On the other hand, Okubo, Picard, and Thisse (2010) prove that, although productive (unproductive) firms choose to locate in large competitive (small less competitive) regions by spatial sorting, high-cost firms could also locate in large markets. Firms located in larger regions benefit from a better proximity to larger pools of customers but need to face tougher competition. Depending on the relative strengths of these two competing forces, different spatial selection patterns emerge in their setting. When regions have very different sizes or when trade costs are very low, firms with low productivity collocate with productive firms in the larger region. Their model indicates that the relation between agglomeration and firm productivity distribution is not monotone as simply captured by the intensification of local competition.[3]

The current paper examines the higher moments of firm-level productivity distributions in Japanese regions to inspect the empirical relevancy of these theoretical predictions.[4]

3. Data description

This section is devoted to the explanations of our micro-data derived from Japan's *Census of Manufacturers*. This census covers virtually all plants across all manufacturing industries.[5]

Although the annual survey covers plants above the given size threshold, small-sized plants are included only in the "census years" (years with a 0, 3, 5, or 8 as its last digit). As the principal purpose of this paper is the investigation of productivity distributions over the entire population of plants, we concentrate on census years to avoid truncations due to the sampling of plants. While plants of any size, including those with only one employee, are covered by the census, plant-level data are maintained only for the plants with no less than five employees in the original micro-data files of the central government even for the most recent census. As a result, our sample excludes plants with less than five employees. Since these extremely small-sized plants produce negligible volumes of output, their omission is unlikely to affect our conclusion on economic geography.

Our sample consists of the following six census years: 1978, 1980, 1983, 1985, 1988, and 1990, since the plant-level data before the mid-1970s are no longer available, even from the original government data files. By using these six consecutive waves of manufacturing censuses,

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3 While Baldwin and Okubo (2006) use the Dixit-Stiglitz monopolistic competition model, Okubo, Picard and Thisse (2010) analyze the varying intensity of price competition in linear demand.
4 We examine whether empirical observations on higher moments are consistent with the predictions implied by these models, though Okubo, Picard and Thisse (2010) consider only two types of firms (high- vs. low-productivity). The firm's productivity is allowed to take continuous values in Baldwin and Okubo (2006).
5 Henderson (2003) studied Marshallian externality based on U.S. *Census of Manufacturers*.

we can investigate the productivity distributions over Japan's history from the oil crises (1973) to the bubble economy (several years prior to 1992). We decide to focus on these earlier years from the following reasons. From the 1990s onward, plant location decisions by Japanese firms have become increasingly global due to expanded production overseas (in particular toward Asia) by Japanese multinationals, accelerated by the unprecedented exchange rate appreciation. No information on offshore production is available in the domestic manufacturing census. By contrast, the 1970s and 1980s, which are the focus of our paper, experienced a transition from high-speed to steady growth. Importantly, the Japanese economy in this period did not experience substantial foreign direct investment, offshoring or international outsourcing. In parallel, this period corresponds to the transition from the bi-polar urban system driven by Tokyo and Osaka to the mono-polar urban system leading to mega-concentration in Metropolitan Tokyo, as suggested by Fujita and Tabuchi (1997). Therefore, the period of the 1970s and 80s, which is our data sample, involves many interesting questions on spatial patterns of firm location and is an appropriate period over which to investigate relationships among firm location, firm productivity and market competition without taking into account overseas production and hollowing-out. As no plant identifier tracing micro-data over time is available for this period, our data set is unfortunately in the format of repeated cross-sections.[6] Since the main target of this paper is the comparison of productivity between core and periphery regions, not on the entry-exit dynamics of plants, this data limitation is unlikely to affect our principal conclusions.

The manufacturing census contains basic information on plant-characteristics, such as output (shipment), and employment (number of regular workers).Whether or not each plant is a

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6 Longitudinal plant identifiers are available only for data after 1986. Instead of using the data after 1986, we focus on earlier period since plant locations in recent years are likely to be strongly driven by international factors, which are beyond the information captured by manufacturing census.

part of a multi-plant firm is also reported, though no identifier is available for linking plants under the same ownership. Hence, the aggregation of our plant-level data to the firm level is impossible from our census data. Since a plant location decision should be affected by the locations of other plants owned by the same firm in the case of multiple-plant firms, we concentrate on the sample of single-plant firms for investigating the distribution of productivity. Since single-plant firms occupy the substantial share in the population of plants (74.5% in 1990), the exclusion of multi-plant firms does not affect our principal results. Our sample of single-plant firms contains as many as 324,687 firms in 1990. By concentrating on single-plant firms, we use “firm” and “plant” interchangeably below.

Appendix Table A presents basic summary statistics of our census data.

4. Empirical results

4.1. Histogram comparisons of productivity across regions

Before investigating the shape parameters of productivity distributions, this section presents how the productivity of firms located in agglomerated core regions differ from that for peripheral regions.

The territory of Japan is divided into 47 prefectures, each of which roughly corresponds to a NUTS2 region.[7] To identify the agglomeration effect, we focus on the three prefectures with the biggest population: Tokyo, Osaka, and Aichi. These prefectures are obvious economic centers and the core regions of Japan, as they account for around 32 percent of industrial output, 26 percent of manufacturing output, 32 percent of GDP, and 22 percent of the population of Japan in 2005. To check the robustness of our focus on these three prefectures, we also examine

[7] See Appendix Table B for the names and codes of prefectures.

the Greater Tokyo Area and the Greater Osaka Area by including neighboring prefectures[8]. This paper defines these regions (Tokyo, Osaka, Aichi, Greater Tokyo, and Greater Osaka) as the core region (Core) and the others as the periphery region.

Figures 1-a to 1-g report the histograms of productivity distribution (frequency in terms of the logarithm of firm productivity) for all firms in Japan combined in (1-a), firms in Tokyo (1-b), Greater Tokyo Area (1-c), Aichi (1-d), Osaka (1-e), Greater Osaka Area (1-f) and Core (1-g), respectively. Productivity is measured by per-worker value-added, since it is practically impossible to estimate the total factor productivity (TFP) of each firm in our repeated cross-section data set without any longitudinal identifier. We note that as some previous studies discussed, the productivity measured by per-worker value-added are not crucially different from other productivity measures.[9] As a robustness check, we also calculate TFP based on longitudinal data for recent years and confirm qualitatively similar patterns.[10] See Figure A in Appendix. Longitudinal plant identifiers are available only after 1986. We focus on earlier period, since plant locations after the mid-1980s are likely to be seriously affected by international factors, which are beyond the scope of this paper.

These graphs demonstrate that the average productivity in all of the core prefectures is clearly higher than that of total Japanese firms.[11] This finding of higher average productivity in

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8 We define Greater Tokyo Area (nation capital area, or *shuto-ken* in Japanese) as Tokyo and neighboring prefectures: Kanagawa, Chiba and Saitama. Greater Osaka Area (Kyoto-Osaka-Kobe Area, or *Keihanshin* in Japanese) is defined as Osaka and the neighboring Kyoto and Hyogo prefectures.

9 The results are unlikely to be qualitatively affected by the choice of productivity measures. See Bernard and Jones (1996), for example.

10 In calculating TFP, we apply the method by Olley and Pakes (1996) to the longitudinal data over 1986-1990 of plants with available data on capital. Appendix Figures A display the results for 1990.

11 By regressing on region dummies, we estimate the average productivity to be around 20-50% higher in core. While the estimation of agglomeration premium is not the target of this paper, this magnitude is larger than previous results from Europe, such as 4.5% at NUTS3 level by Ciccone (2002), 13% at NUTS2 level from Brülhart and Mathys (2008), 3-8% surveyed by Rosenthal and Strange (2004), and 5.8% from meta-analysis by Melo et al. (2009), and also than those from other Japanese data, such as around 15% by Dekle (2002) and Nakamura (2008). As Strange (2009) pointed out, one of the possible reasons should be cross-regional variations in human capital, which

the core confirms previous established empirical results on agglomeration and is consistent with the theoretical prediction on spatial sorting by Baldwin and Okubo (2006). We also test whether the average of the productivity distribution is significantly different between core and peripheral regions, based on the Kolmogorov-Smirnov (KS) test, a non-parametric technique. As all the results from KS tests are statistically significant with zero associated p-values, we confirm that the productivity distribution in the core is significantly different from that in the periphery.[12]

4.2. Distributions of firm productivity

While the previous section inspected whether the productivity at the regional level averaged over heterogeneous firms differs between core versus periphery, we cannot ignore the shape of the productivity distribution, i.e. dispersions and skewness across firms located in the same region. The productivity distributions are analyzed first by visual inspections of distribution graphs and then by estimations the parameters of gamma distributions.

A brief consideration of the productivity distributions displayed in Figure 1 is informative. As the frequency of firms within each productivity interval is measured on the vertical axis, each histogram can be regarded as an empirical counterpart of the probability density. Figure 1-a covers all regions in Japan, while Figure 1-b, 1-d, and 1-e present the corresponding distributions for firms located in Tokyo, Aichi, and Osaka, respectively. Visual inspection of these histograms indicates that firms located in the three core regions tend to distribute over a wider range of productivity compared with the national average. This finding appears to be in contrast to the greater productivity dispersion in smaller local markets observed by Syverson (2004a) in the case of U.S. ready-made concrete.[13] While Syverson (2004a) argues that

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we cannot control for within our micro data.

12 The test statistics are available upon request.

13 Syverson (2004b) compares 443 U.S. manufacturing industries to complement Syverson (2004a), and finds less productivity dispersion in industries with high substitutability, which is proxied by a

intensified competition through cross-product substitution in larger local markets truncates the productivity distribution from below, this paper will examine whether or not other factors, such as externalities, are related to the shape of productivity distribution in the next section.

From the density histograms we also note that the distributions appear to obviously deviate from the normal distribution and are left-skewed. To check the validity of such an impression, we first calculate Kernel density estimates, Figure 2-a to 2-c present the results of this approach. We find that the productivity density is not distributed (log-) normal, but is definitely left-skewed (Figure 2-a). The distribution in core regions appears more left-skewed than that in all of Japan (Figure 2-b). It is also clear that the distribution in core regions is more skewed than that of peripheral regions (Figure 2-c). We confirm that similar patterns remain even if we measure productivity in terms of TFP as shown in Appendix Figure B. We conclude that the distribution of firm productivity in peripheral regions is relatively close to the log-normal distribution while that in core regions is more left-skewed.

Although the Kernel density graphs in Figure 2 clearly demonstrate the core-periphery differences, we cannot exclude the possibility that these cross-regional variations in productivity distributions may be merely due to differences in industrial compositions across regions (due to higher share of high-productivity industries located in core regions).[14] To check this possibility, we present Kernel density estimates for major industries in Figure 3. These industry-specific results confirm that our previous finding is not entirely explained by differences in industrial compositions. Productivity remains on average higher and its distributed is still more left-skewed in core regions than that in periphery even within each industry, though we cannot neglect varying magnitude depending on the industry.

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value/weight ratio or shipped distance.

[14] Holmes and Stevens (2002) show the strong connection between firm size and industry concentration.

Next, we test whether the productivity distribution is (log-) normal or not, using skewness and kurtosis statistics. As a result, the log normality tests for productivity in all prefectures are significantly rejected. Thus we can confirm that the distribution of productivity is *not* log-normal.

Many empirical studies on the distribution of firm size have shown that firm size is subject to log-normal distribution following Gibrat's law. However, recent studies using plant-level data sets, including small business, have derived different outcomes. For example, Cabral and Mata (2003) find that firm distribution is not log-normal and is skewed toward smaller sizes ("right-skewed"), however it evolves over time toward log-normal distribution as firms age. Our finding shows that firm productivity is again not distributed log-normally and is not left-skewed, but becomes more left-skewed as regions are more agglomerated. Before comparing the differences we note that the firm distribution in Cabral and Mata (2003) and other empirical studies is measured in firm size (e.g. employee and profit) rather than in productivity.[15]

As investigated by Cabral and Mata (2003), this paper estimates the extended generalized gamma distribution with a probability density function defined as follows:

$$\frac{|\kappa|}{\Gamma(\kappa^{-2})}(\kappa^{-2})^{\kappa^{-2}}\exp(\kappa^{-2}(\kappa q-\exp(\kappa q)))\quad \kappa\neq 0 \tag{1}$$

$$\frac{1}{\sqrt{2\pi}}\exp(-1/2q^{2})\quad \kappa=0 \tag{2}$$

where $q \equiv (\ln prod - \mu)/\sigma$ is a function of firm productivity, *prod*, μ is its mean, σ its standard deviation and κ is the shape parameter of the gamma distribution. Γ denotes the gamma

15 Barrios, et al. (2005), using Irish manufacturing census data, discovered a firm distribution skewed by financial constraints, but Angelini and Generale (2005), using Italian survey data, suggest no impact of financial constraints on firm distribution. More generally, Angelini and Generale (2008) found that financial constraints have no significant impact on the evolution of firm distribution in OECD countries.

function. As shown in Figure 4, when κ goes to zero, the distribution is (log-) normal distribution, as specified in (2). When κ is more (less) than zero in (1), the distribution is left-skewed (right-skewed).

We now estimate the firm productivity distribution in each prefecture for each year. Table 1 and Figure 5 report the estimation results of κ and σ. All of the κ's are significantly positive (varying in value from 0.3 to 0.8), while σ takes a value around three. This tells us that firm productivity distributions are left-skewed in all 47 prefectures. Given σ, larger positive value of κ (more left-skewed) means that firms with relatively low productivity are more likely to survive, while smaller κ (close to normal distribution) indicates that less productive firms are pushed out possibly due to severe local competition.

We find several interesting outcomes from comparisons across regions.[16] First, the shape parameter κ is quite heterogeneous across regions (the upper panel of Figure 5). While periphery regions geographically far from core regions often exhibit high values (e.g. 0.6-0.7 in Hokkaido, Aomori and Oita), the values in Tokyo and other core regions are not the smallest observed values (the value is around 0.55 in Tokyo). When considering σ, we note that the cross-regional variations are much smaller than in κ (see the middle panel of Figure 5), but core regions tend to have slightly higher values of σ. These results, which are richer than those in Syverson (2004a, b), indicate that the differences in the productivity distribution in the core region compared with that in periphery cannot be monotonically characterized as the result of intensified competition. We might find possible clues in Marshallian externalities or urban externalities, which would mitigate market competition and allow small and low productivity firms to survive in core regions. In the next section, we analyze how this cross-regional difference is explained by underlying economic geography factors, such as market potential.

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16 As shown in Appendix Table C, the basic patterns in the gamma distribution remain the same even if we include multi-plant firms.

Another finding to note is that κ becomes smaller over time in many regions. In particular, κ declines remarkably in many prefectures after the mid-1980s. Furthermore, the decline of κ in periphery regions is substantial (e.g. from 0.7 to 0.5 in the Miyazaki and Nagasaki prefectures).[17] This might indicate that the impact of intensified market competition, which is likely to be accelerated by global competition and the development of domestic transportation networks in the 1980s, became more important in periphery than in core regions.

4.3. Relationships between distribution shapes and economic geography

Keeping our preliminary results on firm distributions in mind, this section relates the estimates reported in the previous section with geographical variables in order to provide economic interpretations.

To investigate how economic geography affects firm productivity distributions, we estimate the following two equations. The dependent variables of the regressions are the shape parameter κ and the standard deviation σ for each prefecture; both are derived from the extended generalized gamma distribution in the last section.[18]

$$\kappa_{jt} = const + \alpha_1 \cdot MP_{jt} + \beta_1 \cdot Urban_{jt} + \gamma_1 \cdot KS_{jt} + \delta_1^Y \cdot YEAR_t + \delta_1^R PREF_j + \varepsilon_{1jt} \quad (3)$$

$$\sigma_{jt} = const + \alpha_2 \cdot MP_{jt} + \beta_2 \cdot Urban_{jt} + \gamma_2 \cdot KS_{jt} + \delta_2^Y \cdot YEAR_t + \delta_2^R PREF_j + \varepsilon_{2jt} \quad (4)$$

The prefecture is indexed by j, while the suffix t denotes the year. On the right-hand side of the regressions, the market potential, *MP,* is defined as in Harris (1954), that is:

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17 The values for some prefectures fluctuate over time (e.g. between 0.3 and 0.5 in Chiba and between 0.3 and 0.6 in Kanagawa). Manufacturing clusters were formed in Kanagawa and Chiba in the 1970s and 80s due to good market access to central Tokyo. Some villages and towns in these prefectures experienced drastic transitions from agricultural to manufacturing areas. This might lead to time varying values of κ.

18 We have also estimated the same specification with the mean μ as the dependent variable. All the main right-hand side variables are significantly positive. The estimation results are omitted from this paper focusing on higher moments, but are available upon request.

$$MP_{jt} \equiv \sum_{n=1}^{47} \frac{GDP_{nt}}{D_{jnt}} \quad (5)$$

where D_{jn} is geographical distance of capitals between prefectures j and n.[19] As a measure of urbanization, we include *Urban*, which is defined as the share of the population in Densely Inhabited Districts (DID) in each region.[20] To check the robustness of the estimates, we also use the following alternative proxies of urbanization: GDP per capita, *Firm* (the total number of manufacturing firms), *Manufacturing* (the share of manufacturing in the region's GDP), and *Infra* (public capital stock for industrial use).[21] To control for cross-regional variations in industrial specialization, we include a value of the Krugman index, which is defined as

$$KS_{jt} \equiv \sum_{i} \left| s_{ijt} - s_{it} \right| \quad (6)$$

where s_{ijt} (s_{it}) denotes the share of industry i in region j (in Japan) in total manufacturing employment.[22] This index takes the value of zero when the region's industrial structure is the same as the national average. While urbanization indices consider the region as a whole, Krugman's index focuses on how the region specializes in a particular industry or how a particular industry is concentrated in the region analyzed. Year dummies *YEAR* and prefecture dummies *PREF* are added in the fixed-effects model applied to our panel data, and error terms are represented by ε.

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19 When j=n, the internal distance is calculated by $\frac{2}{3}\sqrt{\frac{Area}{\pi}}$ where "Area" denotes area of the prefecture j. (See Combes and Overman, 2004)

20 DID is defined by the district of which population density is more than 4,000 people per square kilometer and population in adjacent area is more than 5,000. The data is taken from the Population Census.

21 The prefecture-specific data for GDP, population and infrastructure are taken from Fukao and Yue (2000)'s data set.

22 The estimates κ and σ are region-specific but not industry-specific. However, we have confirmed in Figure 3 that our principal results on productivity distributions are not affected by cross-regional differences in industrial compositions. The addition of the Krugman index to our regression controls for the region's industrial specialization patterns (in deviation from the national average).

Table 2 reports the FGLS panel estimation results. The shape parameter κ in (3) is significantly negatively related to market potential but positively related to urbanization of the region and industrial localization. With respect to the standard deviation σ in (4), the coefficients on market potential, industrial localization and urbanization indices are all significantly positive. These results are robust across alternative indices of urbanization.

Combined with the descriptive statistics reported in previous sections, these regression results are informative in interpreting the core-periphery contrast. Firstly, the productivity distribution tends to have a significantly wider dispersion in urbanized regions. The productivity dispersion is also wider in regions with stronger market potential and regions with localization of industries. These results imply that high average income and demand in urban areas appears to accommodate wide ranges of firms (in productivity but also possibly in differentiated varieties). On the other hand, poor periphery regions with small local demand can support only a narrow range of firms.

This effect of agglomeration on σ has not been detected in previous empirical studies, including Syverson (2004a, b), but in line with the theoretical prediction by Okubo, Picard, and Thisse (2010). In their theoretical model, unproductive firms can survive in urban regions if trade costs are low. As we consider manufacturing industries, the assumption of low trade costs is supposed to be satisfied. Furthermore, their model shows that co-agglomeration is also realized when the regions are very different in sizes. As the difference in market sizes between core vs. periphery is substantial in Japan, the assumption of large size difference is also met here. Consequently, this result reported from our micro data is consistent with the theoretical prediction by Okubo, Picard and Thisse (2010). Our finding of wider productivity dispersion in the cores could also be consistent with the spatial sorting predicted by Baldwin and Okubo (2006), as their model suggests that firms with relatively high productivity relocate to the larger region but those with low productivity remain located in both regions. While we cannot identify within our repeated cross-section data set which selection mechanism is at work in this case, our investigation of higher moments reveals the previously unnoticed nuanced relation with agglomeration.

Secondly, the shape parameter κ in regions with stronger market potentials tends to be significantly lower. This indicates that competition intensified by strong market potential leads the productivity distribution to be relatively close to the normal distribution. This finding is in line with Cabral and Mata (2003) in that both discover that more intense market competition leads to productivity distributions which are closer to the normal distribution.

Thirdly, we find that the shape parameter κ is positively related to the region's urbanization and industrial localization. This implies that urbanized regions, or regions with concentration of specific industries, can accommodate low-productivity firms along a long tail of a left-skewed distribution. Our focus on the shape parameter differentiates us from previous work neglecting higher moments of productivity distributions. Our previous descriptive finding in Figure 5 that the value of κ in core regions is often low, but not extremely low in all such regions, is possibly due to two offsetting effects (κ related positively to urbanization but negatively to market potential). Our regression disentangles agglomeration economies (competition mitigated by general urbanization or by localization of specific industries) from competition intensification effects (competition intensified by market potential), both of which are likely to co-exist in core regions and have been unnoticed in previous empirical research. As far as the authors know, this is the first empirical confirmation of the theoretical prediction by Okubo, Picard, and Thisse (2010).

In sum, the core-periphery contrast is straightforward in the standard deviation σ, as core regions are often urbanized, and have stronger market potentials and higher concentrations of industries. Wider ranges of firms are active in core regions due to large local demand based on the region's high per-capita income, large local market size, or good access to surrounding markets. However, by considering the shape parameter κ, this paper unveils that competition tends to be particularly intense (productivity distribution close to the normal distribution) where the region has strong market potential but is not urbanized or has localization/concentration of no specific industry. This finding suggests that low-productivity firms should be forced to exit low-wage rural regions producing goods for export and is consistent with our observation that only highly productive firms can profitably operate in export-platform locations.

5. Concluding remarks

This paper empirically studies the distribution of firm productivity across regions and finds that the distribution is substantially heterogeneous across regions. There are, however, some aspects not captured by the simple economic geography models. First, there appears no clear cut-off in spatial selection and exists a substantial overlap in firm productivity between core and periphery regions. Second, the distribution of firm productivity is left-skewed and is far from conforming to a log-normal distribution. Third, periphery regions, especially low-income regions with good access to neighboring markets, have tougher competition and productivity distributions are less left-skewed, which might result from trade cost reduction facilitated by the development of transport systems. Finally and much more importantly, the core region has two interacting forces, which have been neglected in previous empirical work concentrating on means and standard deviations of productivity distributions. While the severe competition induced by stronger market potential makes productivity distributions closer to log-normal distributions, the urban externality accommodates firms with wider ranges of productivity to survive within the same market.

The relation between productivity and agglomeration is thus more nuanced than that simply captured by the intensified competition. The firm-level findings reported in this paper are consistent with the theoretical prediction by recent NEG models, especially Okubo, Picard, and Thisse (2010). As the impact of agglomeration on firm distribution is a critical concern for many producers and policy makers, comparable micro-data studies in other countries will be useful in the future.

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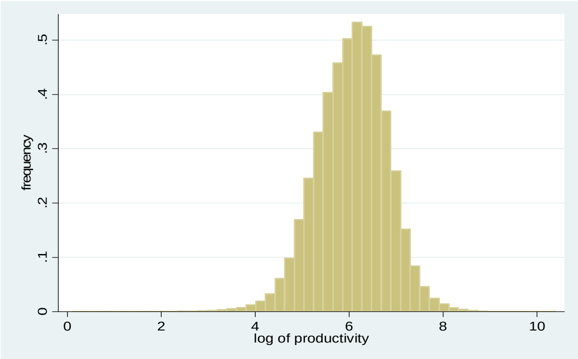
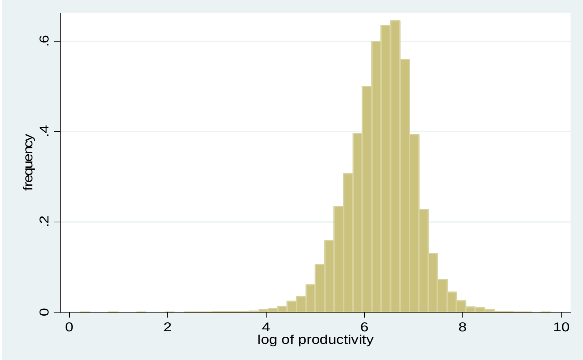
Figure 1: Productivity Distribution (1990)

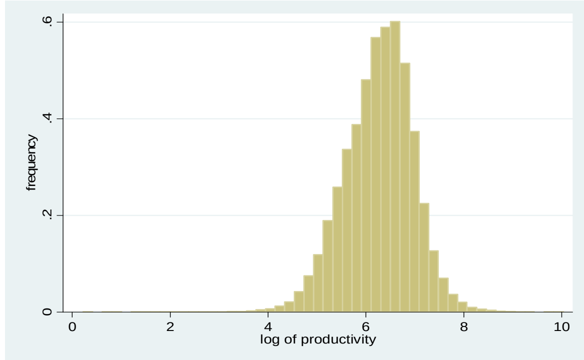
1–a: All regions



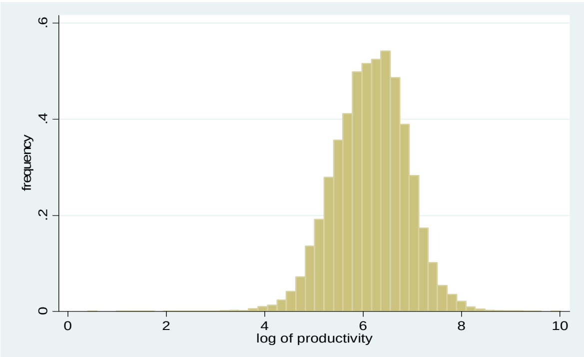
1–b: Tokyo



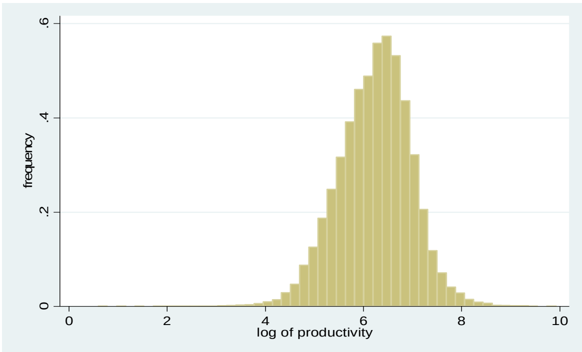
1–c: Greater Tokyo



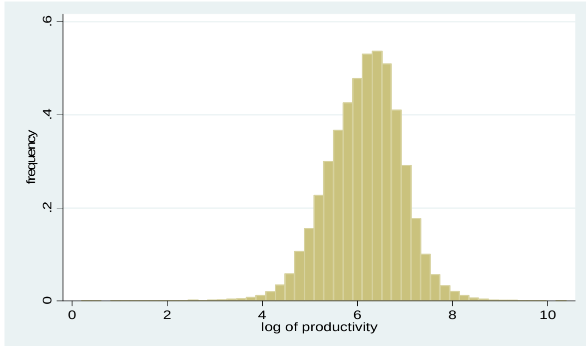
1–d: Aichi



1–e: Osaka



1–f: Greater Osaka



1–g: Core regions

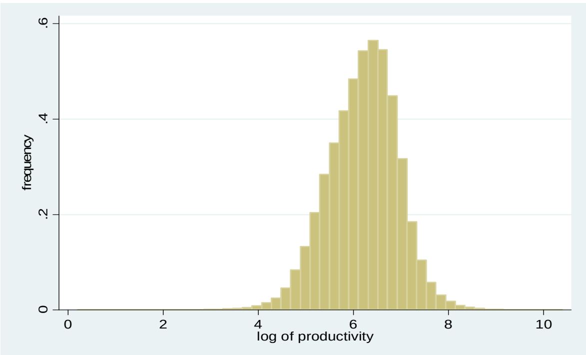
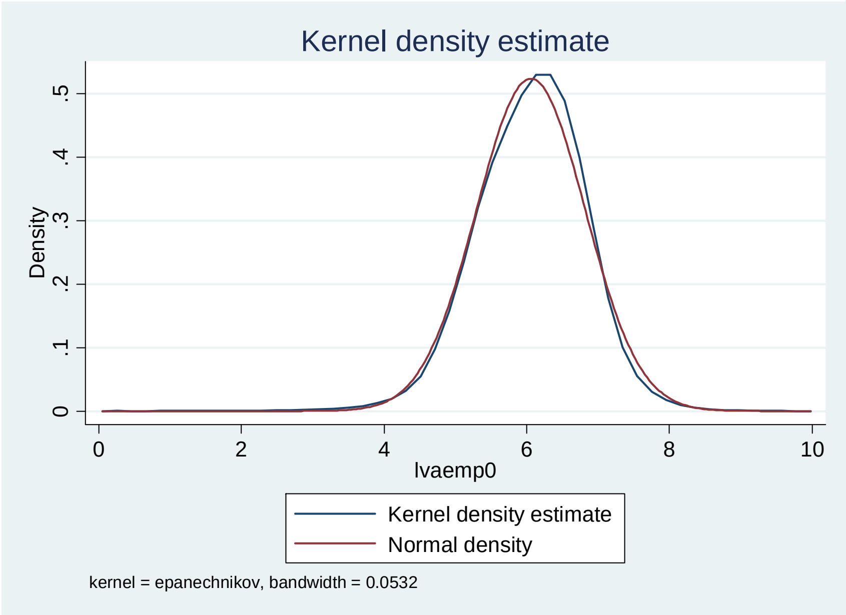
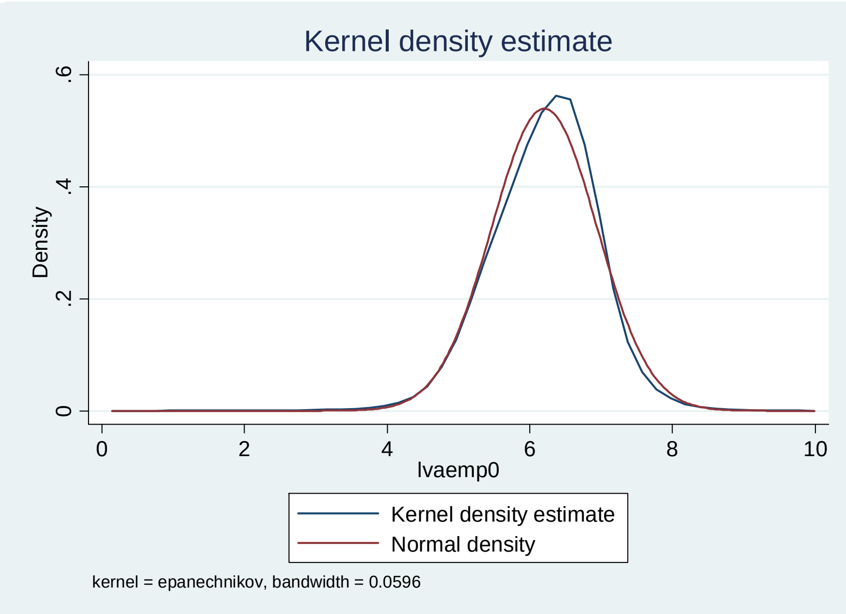


Figure 2: Kernel Density and Normal Distribution (1990)

All regions



Core



Kernel density in Core and Periphery

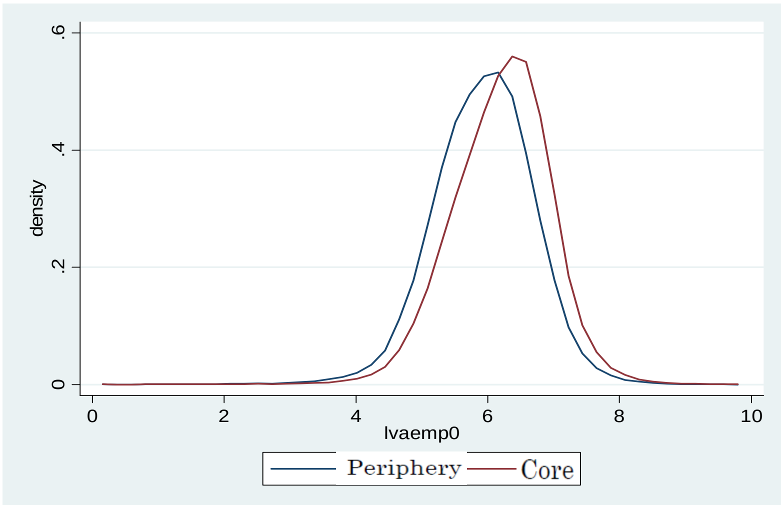
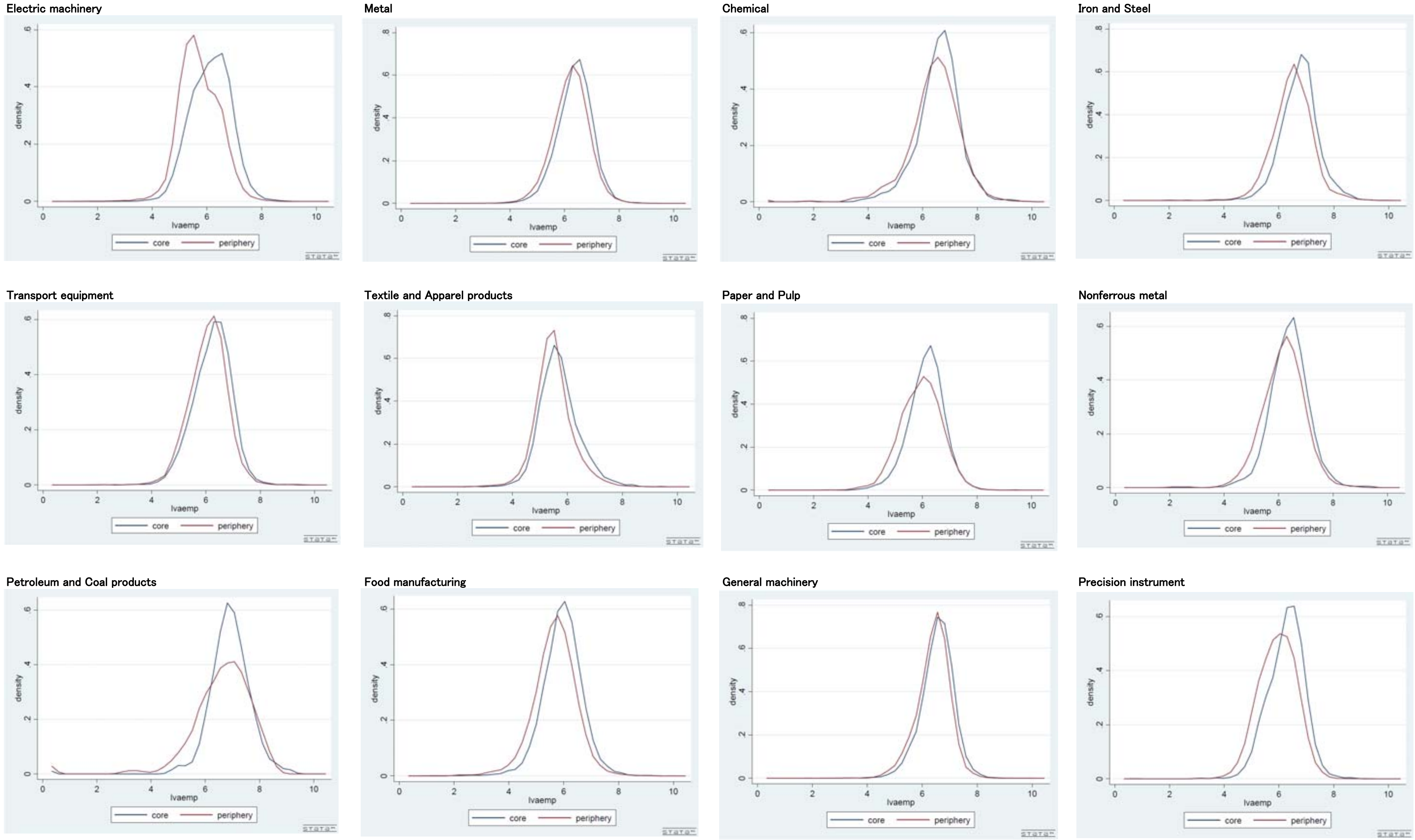


Figure 3: Kernel Density in Representative Sectors



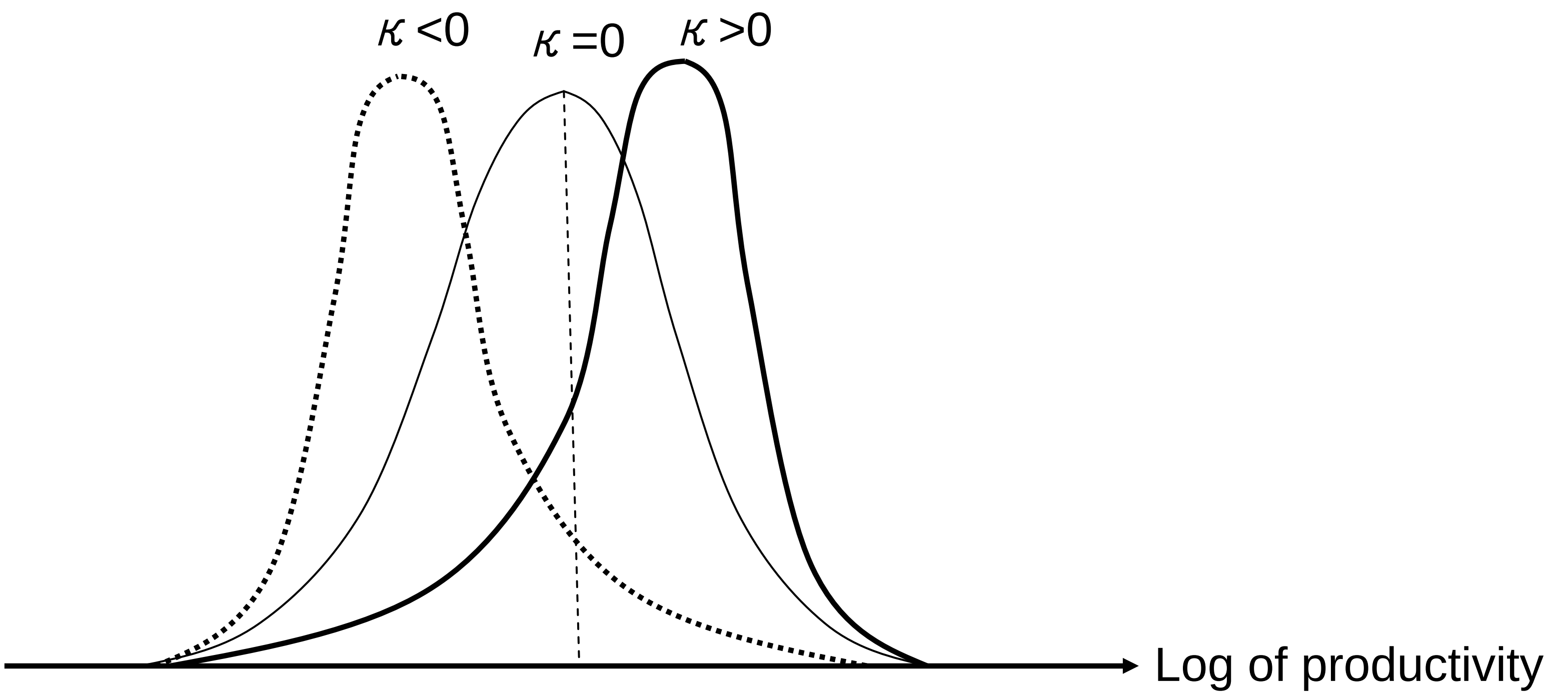
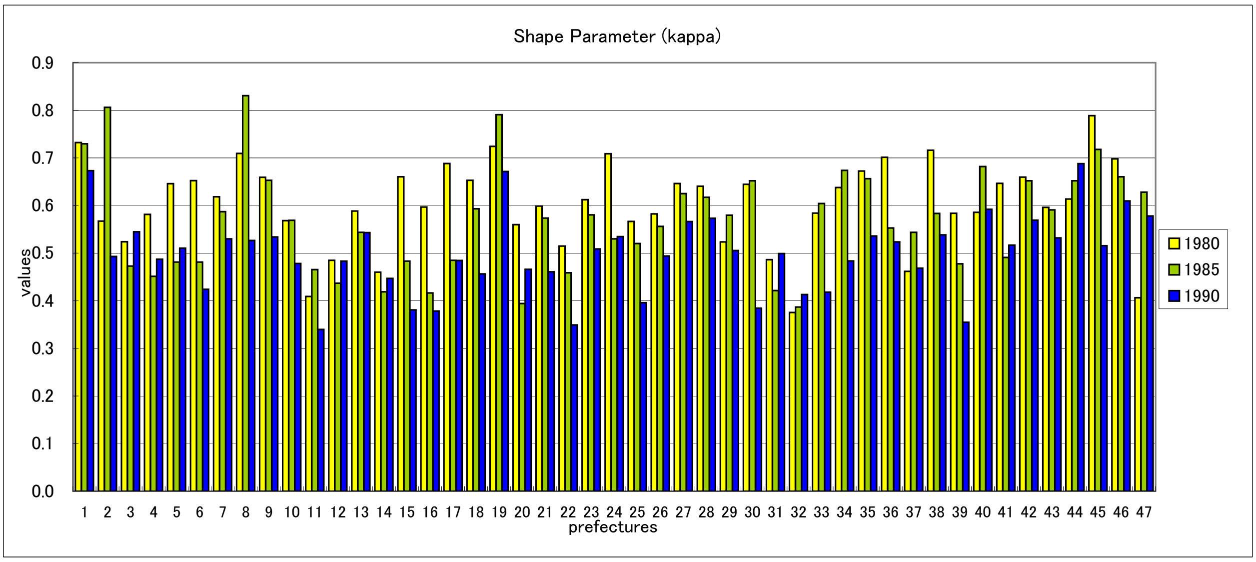
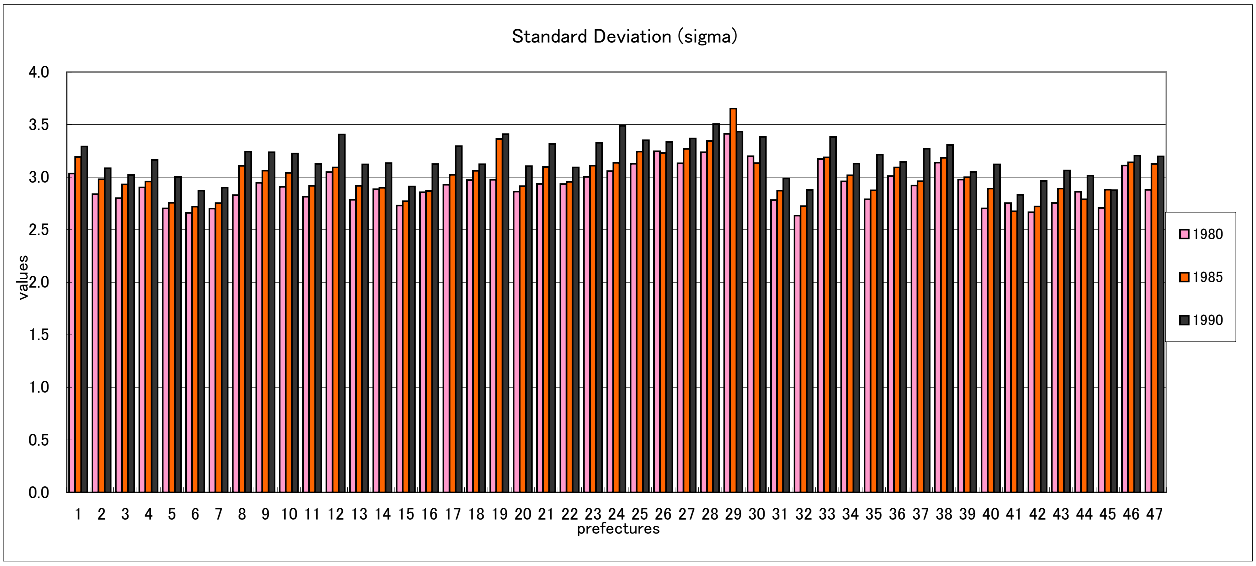


Figure 4: Gamma distribution and shape parameters (κ)

Figure 5: Gamma distribution estimates





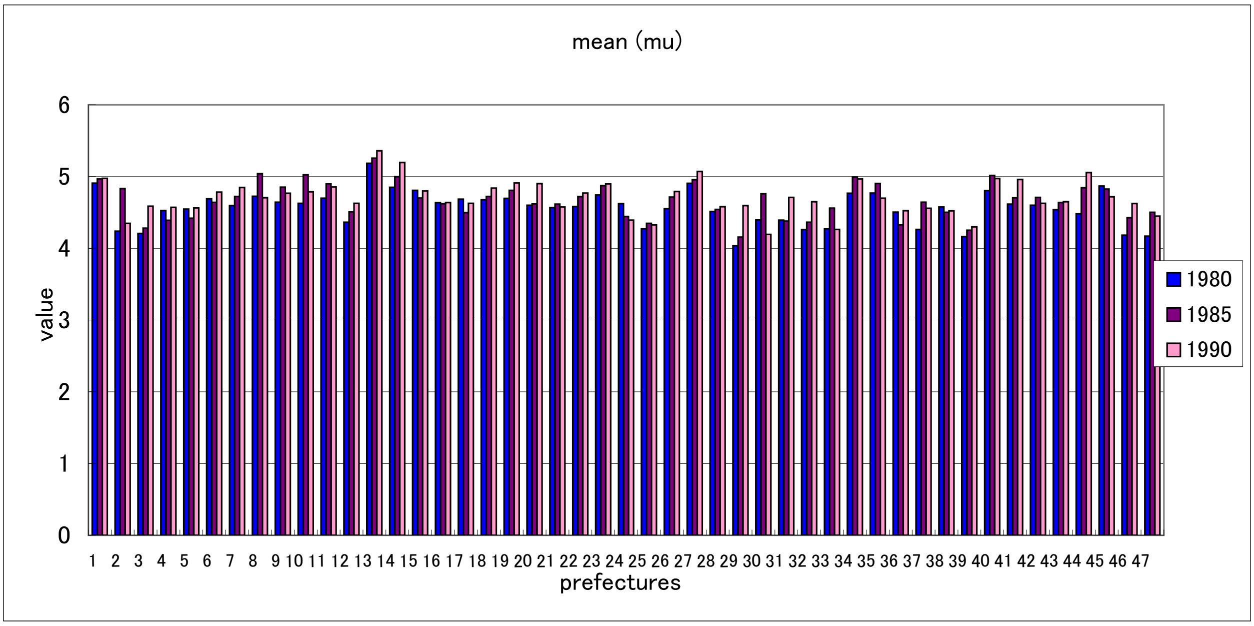


Table 1: Gamma Distribution

	1978			1980			1983			1985			1988			1990		
Code	σ	κ	μ	σ	κ	μ	σ	κ	μ	σ	κ	μ	σ	κ	μ	σ	κ	μ
Total	2.880	0.585	4.544	3.015	0.591	4.641	3.062	0.582	4.710	3.124	0.577	4.755	3.161	0.542	4.808	3.293	0.492	4.761
	*839.15***	*200.37***	*667.12***	*872.35***	*203.01***	*650.64***	*899.31***	*204.85***	*666.1***	*899.83***	*203.52***	*658.36***	*904.99***	*191.1***	*661.34***	*928.03***	*168.11***	*625.79***
1	2.955	0.763	4.804	3.034	0.732	4.909	3.087	0.721	4.957	3.192	0.730	4.966	3.199	0.683	5.051	3.291	0.673	4.976
	*130.74***	*40.7***	*102.55***	*131.66***	*37.83***	*99.57***	*129.56***	*35.85***	*95.61***	*125.75***	*32.99***	*84.89***	*127.82***	*31.05***	*87.62***	*129.67***	*30.66***	*85.34***
2	2.753	0.649	4.392	2.838	0.567	4.238	2.859	0.699	4.637	2.979	0.806	4.833	3.057	0.806	4.898	3.085	0.493	4.347
	*62.17***	*16.6***	*50.48***	*62.84***	*13.61***	*46.83***	*62.95***	*18.27***	*51.32***	*62.83***	*20.91***	*49.28***	*63.44***	*20.33***	*47.38***	*65.4***	*10.57***	*41.19***
3	2.739	0.691	4.369	2.800	0.524	4.208	2.870	0.404	4.128	2.930	0.473	4.280	2.890	0.519	4.535	3.021	0.545	4.586
	*64.05***	*19.81***	*54.64***	*66.1***	*13.48***	*50.23***	*67.75***	*8.56***	*43.34***	*69.88***	*11.39***	*47.03***	*69.83***	*13.91***	*53.93***	*75.04***	*15.86***	*55.49***
4	2.736	0.479	4.321	2.902	0.581	4.527	2.958	0.583	4.560	2.959	0.451	4.390	3.093	0.566	4.634	3.164	0.487	4.572
	*80.93***	*15.41***	*66.75***	*87.07***	*20.75***	*69.06***	*88.12***	*20.82***	*68.28***	*87.26***	*15.01***	*65.21***	*92.45***	*21.17***	*69.01***	*92.56***	*16.96***	*64.57***
5	2.522	0.314	4.134	2.703	0.646	4.548	2.693	0.353	4.215	2.756	0.481	4.419	2.883	0.480	4.446	3.001	0.511	4.562
	*63.98***	*7.16***	*54.62***	*66.31***	*18.87***	*59.85***	*67.53***	*8.62***	*54.1***	*67.95***	*14.43***	*60.6***	*73.35***	*14.13***	*58.11***	*75.44***	*13.86***	*53.27***
6	2.675	0.512	4.267	2.661	0.652	4.690	2.693	0.485	4.563	2.719	0.481	4.640	2.785	0.347	4.566	2.872	0.424	4.784
	*81.84***	*17.09***	*68.92***	*80.32***	*24.17***	*78.06***	*82.3***	*16.25***	*73.46***	*82.95***	*16.75***	*75.88***	*86.16***	*11.07***	*72.1***	*89.11***	*14.55***	*74.91***
7	2.624	0.641	4.440	2.701	0.619	4.596	2.762	0.741	4.886	2.753	0.587	4.723	2.812	0.611	4.862	2.901	0.530	4.848
	*94.19***	*26.11***	*84.7***	*96.13***	*24.39***	*83.01***	*98.79***	*31.39***	*88.03***	*98.5***	*23.03***	*84.26***	*102.12***	*25.89***	*88.81***	*105.64***	*22.21***	*87.27***
8	2.675	0.628	4.511	2.829	0.709	4.725	2.871	0.562	4.592	3.107	0.831	5.040	3.095	0.567	4.721	3.243	0.527	4.705
	*101.8***	*27.82***	*91.13***	*109.93***	*33.35***	*92.62***	*118.05***	*26.26***	*93.18***	*122.38***	*40.56***	*90.35***	*126.98***	*27.65***	*91.51***	*132.33***	*25.62***	*88.25***
9	2.788	0.570	4.424	2.946	0.659	4.643	3.037	0.656	4.712	3.062	0.653	4.853	3.091	0.569	4.783	3.237	0.534	4.769
	*110.36***	*25.6***	*89.13***	*114.63***	*29.82***	*86.38***	*123.36***	*32.09***	*91.32***	*122.11***	*31.02***	*90.43***	*124.55***	*27.64***	*92.19***	*128.34***	*25.77***	*88.48***
10	2.822	0.551	4.469	2.908	0.568	4.627	2.962	0.584	4.753	3.041	0.569	5.026	3.234	0.809	5.188	3.224	0.478	4.788
	*121.8***	*27.28***	*98.38***	*126.06***	*28.71***	*99.69***	*132.08***	*31.8***	*106.38***	*134.03***	*31.08***	*104.55***	*141.93***	*46.81***	*105.69***	*142.22***	*25.86***	*101.35***
11	2.746	0.488	4.663	2.814	0.409	4.698	2.837	0.434	4.815	2.917	0.465	4.898	2.947	0.363	4.852	3.127	0.340	4.855
	*166.93***	*34.94***	*152.75***	*173.76***	*28.3***	*150.95***	*185.03***	*34.32***	*168.77***	*187.68***	*38.32***	*169.04***	*194.07***	*28.98***	*168.95***	*203.51***	*25.7***	*155.35***
12	2.855	0.436	4.244	3.048	0.485	4.365	3.010	0.482	4.540	3.092	0.437	4.506	3.231	0.334	4.367	3.406	0.483	4.626
	*113.61***	*18.06***	*82.85***	*120.38***	*21.53***	*82.33***	*123.66***	*22.71***	*90.83***	*124.26***	*19.25***	*85.04***	*132.71***	*13.79***	*79.07***	*133.81***	*22.05***	*79.75***
13	2.635	0.534	5.014	2.785	0.589	5.185	2.909	0.589	5.221	2.917	0.544	5.257	2.937	0.540	5.363	3.121	0.543	5.359
	*281.21***	*68.42***	*298.44***	*291.66***	*75.09***	*285.76***	*300.89***	*74.09***	*272.62***	*293.39***	*67.54***	*271.11***	*280.2***	*63.67***	*261.09***	*283.11***	*59.46***	*232.71***
14	2.846	0.643	4.959	2.885	0.460	4.850	2.818	0.357	4.850	2.899	0.419	4.998	2.988	0.400	5.051	3.134	0.447	5.196
	*151.45***	*42.22***	*136.73***	*154.52***	*28.4***	*132.84***	*157.35***	*22.4***	*143.64***	*160.36***	*28.54***	*148.04***	*165.58***	*26.23***	*142.42***	*171.79***	*31.51***	*143.77***
15	2.653	0.625	4.613	2.730	0.660	4.809	2.741	0.506	4.649	2.771	0.483	4.701	2.829	0.514	4.871	2.911	0.381	4.800
	*124.33***	*34.1***	*115.76***	*129.25***	*39.16***	*123.41***	*129.61***	*27.19***	*116.14***	*128.79***	*26.54***	*117.32***	*129.53***	*27.57***	*115.47***	*133.19***	*19.02***	*109.78***
16	2.715	0.504	4.400	2.856	0.597	4.636	2.811	0.453	4.600	2.869	0.416	4.620	2.898	0.360	4.673	3.125	0.379	4.639
	*82.01***	*17.45***	*71.54***	*85.71***	*20.52***	*69.45***	*88.09***	*15.57***	*73.57***	*89.19***	*14.42***	*73.19***	*91.52***	*11.65***	*71.9***	*96.46***	*12.11***	*65.72***
17	2.830	0.714	4.612	2.928	0.688	4.685	2.992	0.608	4.640	3.022	0.485	4.498	3.124	0.660	4.920	3.295	0.485	4.628
	*107.57***	*30.73***	*84.38***	*111.89***	*30.62***	*85.77***	*115.44***	*27.91***	*87.09***	*113.3***	*20.56***	*81.6***	*113.18***	*30.26***	*85.78***	*118.85***	*19.85***	*75.14***
18	2.780	0.649	4.566	2.972	0.653	4.677	2.944	0.470	4.557	3.060	0.593	4.723	3.019	0.477	4.756	3.123	0.456	4.840
	*89.32***	*23.62***	*72.83***	*92.15***	*21.83***	*64.82***	*97.21***	*16.43***	*70.82***	*96.31***	*21.34***	*69.01***	*93.83***	*17.49***	*73.51***	*97.33***	*16.72***	*72.3***
19	2.859	0.777	4.706	2.976	0.724	4.697	3.207	0.676	4.577	3.364	0.791	4.809	3.140	0.568	4.752	3.409	0.671	4.911
	*72.56***	*23.53***	*58.14***	*77.26***	*21.81***	*56.8***	*84.83***	*20.35***	*52.31***	*86.96***	*24.61***	*51.89***	*85.42***	*17.67***	*58.65***	*90.94***	*22.37***	*57.11***
20	2.738	0.496	4.407	2.862	0.560	4.600	2.921	0.480	4.571	2.915	0.394	4.617	2.965	0.420	4.760	3.104	0.466	4.902
	*123.89***	*25.89***	*106.91***	*129.2***	*30***	*106.72***	*134.15***	*25.43***	*106.48***	*132.4***	*19.79***	*105.66***	*132.56***	*21.94***	*108.17***	*137.87***	*25.64***	*108.28***
21	2.826	0.573	4.435	2.935	0.599	4.566	3.042	0.627	4.650	3.098	0.574	4.616	3.226	0.535	4.605	3.317	0.461	4.576
	*140.4***	*30.27***	*105.06***	*149.3***	*33.14***	*107.34***	*155.52***	*37.09***	*110.36***	*157.67***	*33.64***	*108.74***	*164.65***	*31.14***	*104.83***	*166.34***	*24.37***	*96.85***
22	2.793	0.540	4.538	2.935	0.515	4.582	2.950	0.522	4.697	2.956	0.459	4.722	3.006	0.442	4.828	3.092	0.349	4.771
	*168.48***	*36.22***	*138.13***	*176.75***	*33.47***	*131.2***	*183.3***	*37.4***	*144.42***	*183.51***	*34.09***	*150.66***	*184.79***	*32.65***	*150.46***	*188.75***	*24.53***	*144.34***
23	2.930	0.656	4.679	3.002	0.612	4.744	3.054	0.613	4.840	3.109	0.580	4.873	3.191	0.590	4.972	3.326	0.509	4.898
	*239.39***	*63.12***	*185.17***	*247.05***	*59.95***	*188.37***	*254.22***	*60.39***	*190.04***	*256.25***	*58.26***	*192***	*260.05***	*58.88***	*189.29***	*269.03***	*50.57***	*182.99***
24	2.925	0.681	4.433	3.058	0.709	4.622	3.049	0.681	4.695	3.137	0.530	4.443	3.316	0.572	4.478	3.488	0.535	4.392
	*108.45***	*30.08***	*80.83***	*112.44***	*31.09***	*79.02***	*116.21***	*31.34***	*84.96***	*118.14***	*22.68***	*78.01***	*123.05***	*25.71***	*76.13***	*127.96***	*23.87***	*72.02***
25	2.941	0.517	4.148	3.128	0.567	4.271	3.162	0.663	4.561	3.244	0.520	4.348	3.284	0.467	4.362	3.352	0.396	4.326
	*84.05***	*17.94***	*61.84***	*87.74***	*18.56***	*56.23***	*90.44***	*24.18***	*62.7***	*90.08***	*15.99***	*53.39***	*91.56***	*15.45***	*56.89***	*93.45***	*14.06***	*59.77***
26	3.164	0.658	4.599	3.247	0.582	4.551	3.186	0.620	4.818	3.230	0.556	4.713	3.352	0.606	4.863	3.334	0.494	4.793
	*146.13***	*35.56***	*95.34***	*147.78***	*29.63***	*90.04***	*150.8***	*33.93***	*101.71***	*147.25***	*29.43***	*97.16***	*147.99***	*32.72***	*95.82***	*145.09***	*25.27***	*93.93***
27	2.971	0.635	4.811	3.132	0.646	4.906	3.206	0.670	4.987	3.268	0.625	4.956	3.260	0.608	5.064	3.367	0.566	5.072
	*280.5***	*71.25***	*220.09***	*292.62***	*72.5***	*211.99***	*304.94***	*77.76***	*216.32***	*305.06***	*71.16***	*209.41***	*303.04***	*70.68***	*217.87***	*307.77***	*64.44***	*209.86***
28	3.005	0.600	4.437	3.237	0.641	4.514	3.269	0.650	4.604	3.344	0.617	4.542	3.328	0.566	4.586	3.505	0.573	4.581
	*180.62***	*41.69***	*127.65***	*189.69***	*44.05***	*118.02***	*194.09***	*45.9***	*121.54***	*194.28***	*42.16***	*115.59***	*194.68***	*39.7***	*121.55***	*201.68***	*40.82***	*116.5***
29	3.187	0.644	4.253	3.412	0.524	4.034	3.582	0.476	3.924	3.652	0.580	4.155	3.391	0.504	4.506	3.433	0.506	4.595
	*96.14***	*23.45***	*59.18***	*99.56***	*16.44***	*48.77***	*107.11***	*13.75***	*43.48***	*107.41***	*19.39***	*48.64***	*101.09***	*16.09***	*55.08***	*101.02***	*16.17***	*55.53***
30	3.052	0.635	4.364	3.198	0.645	4.395	3.130	0.586	4.498	3.134	0.652	4.760	3.306	0.555	4.459	3.383	0.384	4.194
	*90.08***	*20.99***	*58.45***	*92.08***	*21.45***	*56.49***	*93.63***	*20.49***	*62.8***	*91.28***	*23.06***	*64.79***	*93.41***	*18.36***	*56.65***	*95.78***	*11.68***	*52.46***
31	2.595	0.496	4.456	2.782	0.486	4.392	2.737	0.406	4.411	2.872	0.421	4.380	2.990	0.570	4.712	2.988	0.499	4.710
	*46.45***	*9.08***	*41.58***	*52.31***	*10.27***	*43.24***	*51.22***	*8.21***	*43.45***	*51.95***	*7.81***	*38.62***	*52.95***	*10.7***	*37.55***	*54.64***	*9.92***	*40.7***
32	2.480	0.430	4.316	2.634	0.375	4.262	2.605	0.335	4.324	2.723	0.387	4.363	2.846	0.506	4.641	2.878	0.413	4.650
	*54.08***	*10.03***	*54.13***	*57.11***	*8.27***	*49.4***	*57.55***	*7.57***	*52.56***	*60.02***	*9.96***	*54.56***	*62.17***	*13.19***	*53.25***	*62.31***	*9.31***	*48.86***
33	2.959	0.626	4.334	3.174	0.584	4.269	3.178	0.630	4.487	3.188	0.604	4.560	3.204	0.303	4.146	3.382	0.418	4.264
	*107.22***	*26.59***	*76.15***	*114.23***	*24.59***	*70.56***	*115.55***	*27.48***	*75.02***	*113.55***	*25.78***	*74.78***	*116.02***	*10.45***	*65.55***	*119.51***	*16.94***	*68.65***
34	2.815	0.524	4.491	2.959	0.638	4.769	2.884	0.603	4.876	3.018	0.674	4.993	3.049	0.608	5.027	3.129	0.484	4.966
	*117.99***	*24.14***	*94.47***	*122.4***	*31.32***	*96.24***	*123.37***	*30.54***	*104.71***	*125.99***	*35.42***	*103.09***	*126***	*31.49***	*102.14***	*129.35***	*24.53***	*100.36***
35	2.631	0.594	4.545	2.790	0.672	4.770	2.794	0.666	4.889	2.874	0.656	4.905	3.015	0.628	4.892	3.214	0.536	4.700
	*71.48***	*19.73***	*70.3***	*73.81***	*21.74***	*66.37***	*74***	*21.62***	*67.76***	*72.07***	*19.68***	*61.79***	*74.08***	*17.88***	*56.74***	*79.23***	*14.68***	*51.41***
36	2.725	0.495	4.165	3.010	0.702	4.504	3.033	0.592	4.351	3.093	0.553	4.325	3.008	0.504	4.465	3.144	0.524	4.524
	*68.46***	*15.04***	*58.57***	*71.72***	*19.92***	*50.91***	*75.68***	*18.35***	*54.84***	*74.54***	*15.33***	*49.29***	*72.7***	*13.54***	*51.64***	*74.67***	*14.79***	*51.62***
37	2.849	0.526	4.274	2.921	0.462	4.263	2.953	0.660	4.720	2.962	0.544	4.644	3.054	0.466	4.580	3.271	0.469	4.559
	*81.92***	*15.6***	*58.69***	*85.28***	*13.82***	*59.26***	*86.54***	*23.35***	*68.22***	*85.04***	*17.87***	*65.1***	*89***	*15.64***	*65.17***	*92.7***	*15.53***	*59.85***
38	3.003	0.514	4.096	3.138	0.716	4.577	3.150	0.578	4.381	3.183	0.583	4.502	3.178	0.643	4.732	3.306	0.539	4.523
	*92.33***	*15.91***	*55.75***	*97.26***	*26.83***	*64.88***	*99.35***	*21.17***	*63.84***	*99.5***	*21.98***	*65.63***	*97.04***	*24.61***	*68.03***	*100.86***	*20.41***	*64.71***
39	2.987	0.596	4.044	2.977	0.584	4.163	3.034	0.479	4.109	2.999	0.477	4.253	3.109	0.549	4.476	3.051	0.355	4.300
	*61.79***	*15.02***	*43.12***	*60.56***	*14.8***	*44.59***	*63.66***	*11.29***	*42.59***	*62.02***	*11.61***	*44.89***	*62.55***	*13.59***	*44.39***	*61.27***	*8.42***	*45.14***
40	2.552	0.603	4.741	2.702	0.586	4.803	2.704	0.539	4.849	2.891	0.682	5.016	2.957	0.612	5.017	3.121	0.592	4.972
	*114.86***	*31.73***	*119.65***	*121.24***	*31.89***	*117.61***	*120.09***	*28.4***	*117.06***	*125.04***	*37.22***	*111.6***	*129.58***	*33.57***	*111.5***	*134.69***	*31.78***	*104.42***
41	2.538	0.613	4.618	2.753	0.646	4.616	2.620	0.549	4.761	2.675	0.491	4.703	2.807	0.566	4.885	2.832	0.517	4.960
	*53.28***	*14.66***	*53.55***	*57.57***	*15.87***	*50.32***	*54.55***	*12.18***	*51.49***	*56.9***	*11.63***	*53.4***	*59.06***	*14.15***	*53.37***	*59.73***	*12.56***	*53.46***
42	2.520	0.667	4.515	2.667	0.660	4.600	2.679	0.571	4.533	2.722	0.652	4.709	2.748	0.438	4.488	2.962	0.569	4.626
	*62.84***	*20.54***	*65.95***	*67.45***	*20.32***	*63.35***	*69.26***	*17.59***	*64.4***	*68.7***	*20.07***	*63.81***	*68.73***	*11.67***	*57.72***	*72.95***	*16.74***	*56.9***
43	2.617	0.456	4.214	2.755	0.596	4.539	2.783	0.416	4.394	2.892	0.591	4.638	2.972	0.595	4.761	3.064	0.532	4.650
	*70.85***	*12.6***	*60.07***	*74.27***	*18.74***	*64***	*75.85***	*11.49***	*59.65***	*76.84***	*18.87***	*62.94***	*78.2***	*18.8***	*61.74***	*79.42***	*15.2***	*55.87***
44	2.775	0.658	4.478	2.861	0.614	4.479	2.881	0.680	4.742	2.789	0.652	4.843	2.809	0.712	5.097	3.014	0.688	5.056
	*63.88***	*17.47***	*52.46***	*66.35***	*16.98***	*53.54***	*64.95***	*17.84***	*52.25***	*62.77***	*18.27***	*58.02***	*62.29***	*20.48***	*60.22***	*65.04***	*18.64***	*53.61***
45	2.531	0.627	4.552	2.707	0.789	4.869	2.776	0.611	4.628	2.881	0.718	4.827	2.841	0.550	4.671	2.877	0.516	4.719
	*53.41***	*14.45***	*51.57***	*57.86***	*20.53***	*54.7***	*57.92***	*13.59***	*46.92***	*60.01***	*17.82***	*49.41***	*60.99***	*13.52***	*50.8***	*61.2***	*11.49***	*47.69***
46	2.930	0.653	4.171	3.111	0.698	4.184	3.047	0.560	4.223	3.141	0.660	4.426	3.117	0.382	4.196	3.205	0.610	4.625
	*77.93***	*20.21***	*54.01***	*80.88***	*21.89***	*51.68***	*81.21***	*17.29***	*54.27***	*80.5***	*21.16***	*54.69***	*78.7***	*9.79***	*48.12***	*78.83***	*18.24***	*52.68***
47	2.929	0.761	4.641	2.879	0.406	4.170	3.073	0.924	4.971	3.126	0.628	4.502	3.073	0.676	4.533	3.198	0.578	4.449
	*44.2***	*12.64***	*31.47***	*45.5***	*5.4***	*27.81***	*49.08***	*17.23***	*34.87***	*50.2***	*10.26***	*29.89***	*50.46***	*12.17***	*33.74***	*50.84***	*8.98***	*28.38***

**: significant at 5%

Bottom line in each estimate is z-value.

Table 2: FGLS Results on Productivity Distribution Heterogeneity

	1	2	3	4	5	6	7	8
Dependent variables	κ	κ	κ	κ	σ	σ	σ	σ
MKT	−0.0761	−0.0564	−0.0616	−0.0546	0.11967	0.10119	0.11182	0.1117
	[−7.62]**	[−5.92]**	[−6.14]**	[−5.07]**	[8.74]**	[5.66]**	[6.29]**	[8.08]**
KS	0.0961	0.0903	0.1371	0.0676	0.15951	0.19513	0.17544	0.09059
	[2.73]**	[2.60]**	[3.71]**	[1.93]*	[3.60]**	[4.11]**	[3.69]**	[1.92]*
Urban	0.0839			0.0983	0.18495		0.15916	0.33173
	[2.60]**			[2.30]**	[4.44]**		[3.27]**	[6.43]**
Firm	0.0333					0.03901	0.01354	
	[4.13]**					[3.42]**	[1.00]	
GDPcapita		0.0729						
		[2.61]**						
Manufacturing			0.0405					
			[6.41]**					
Infla		0.0322		0.0231				−0.06545
		[4.10]**		[2.20]**				[−4.01]**
Wald Chi−2	175.63	172.62	140.74	142.42	725.47	714.14	732.49	772.36

constant term is omitted
time dummies are omitted
FGLS panal with heteroskedastic but uncorrelated error structure
Number of observations is 282. Number of groups is 47.
[ ]: z−values
** 5%   * 10% significance

Figure A: TFP distribution (1990)

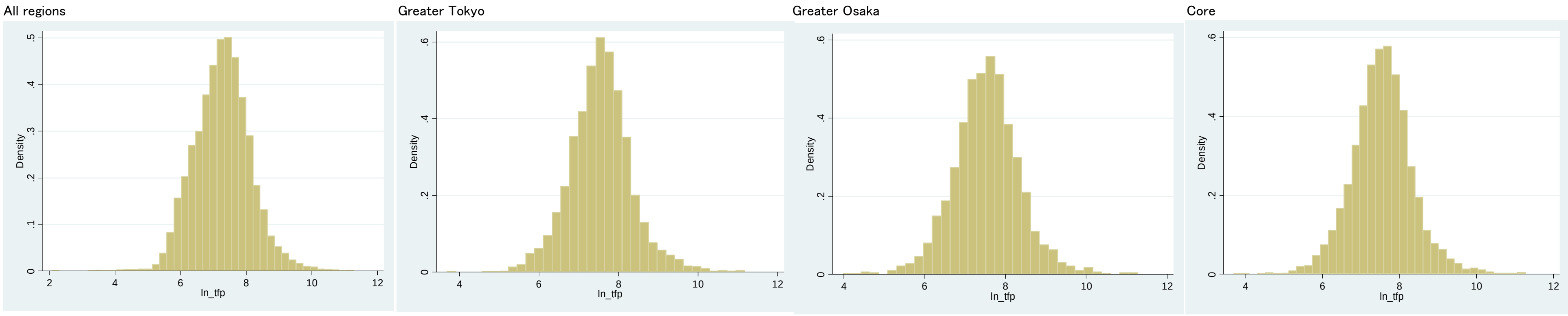
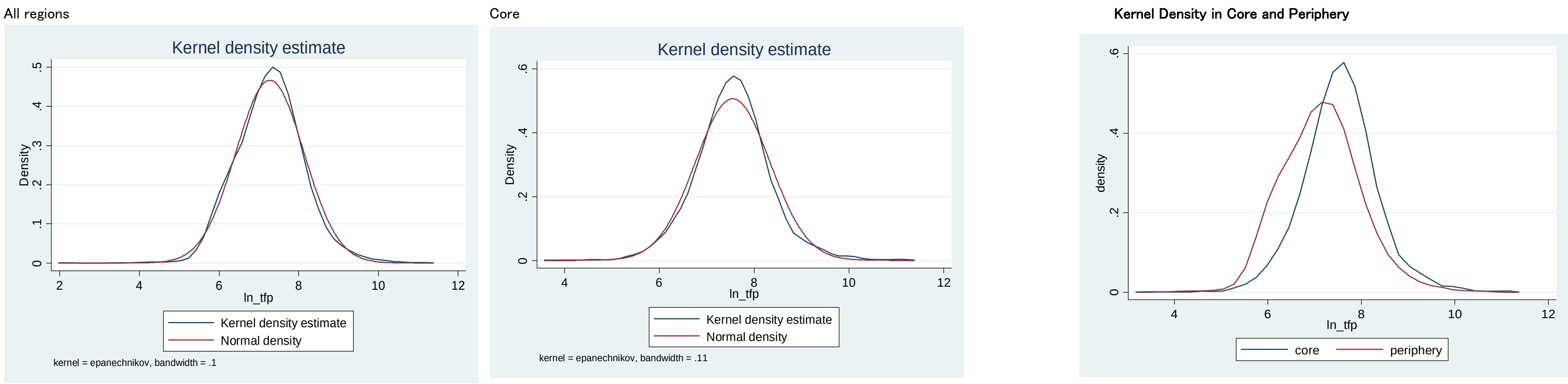


Figure B: Kernel density and Normal distributions in TFP (1990)



Appendix

Table A: Basic Statistic

Firm productivity (in logarithm)

	1978	1980	1983	1985	1988	1990
Obs	348683	346333	355323	339814	332982	324687
Mean	5.466605	5.617749	5.712944	5.79242	5.902257	6.025851
Std. Dev.	0.807285	0.831771	0.829244	0.848545	0.832791	0.87742
Variance	0.651709	0.691843	0.687645	0.720028	0.693541	0.769866
Skewness	−1.30789	−1.46736	−1.46885	−1.64182	−1.59998	−1.8487
Kurtosis	10.96468	11.97741	12.03113	12.98473	13.01716	14.1606
percentail						
1%	3.386809	3.461262	3.555348	3.555348	3.772761	3.713572
5%	4.265025	4.394449	4.493121	4.564348	4.688521	4.774913
10%	4.564348	4.701616	4.795791	4.864967	4.976734	5.081404
25%	5.01728	5.166164	5.253582	5.331107	5.4375	5.55511
50%	5.509388	5.664695	5.766131	5.849325	5.959071	6.0898
75%	5.966916	6.126869	6.222472	6.316391	6.425949	6.570683
90%	6.367157	6.531461	6.620586	6.709914	6.809388	6.96755
95%	6.622838	6.790097	6.878326	6.958528	7.054782	7.210966
99%	7.200612	7.388603	7.473702	7.538894	7.617444	7.76797

Regression Variables

Variables	Obs	Mean	Std.Dev	Min	Max
κ	282	0.561326	0.106034	0.303	0.924
σ	282	2.983004	0.214936	2.48	3.652
μ	282	4.622996	0.257272	3.92427	5.362784
MKT	282	14.0643	0.632308	12.31976	15.91758
KS	282	0.529467	0.15348	0.242133	1.046072
urban	282	0.433502	0.180862	0.209756	0.969981
Firm	282	8.750307	0.824496	7.131699	10.90658
GDPcapita	282	0.801253	0.290592	0.121016	1.963593
Inf	282	14.01443	0.660407	12.65949	15.94146
GDP	282	15.26669	0.858726	13.71362	18.2519

Table B: Japanese Prefecture Code

Prefecture Code	Pref Name	Area Name	Core
1	Hokkaido		
2	Aomori		
3	Iwate		
4	Miyagi		
5	Akita		
6	Yamagata		
7	Fukushima		
8	Ibaraki		
9	Tochigi		
10	Gunma		
11	**Saitama**	Greater Tokyo	Core
12	**Chiba**	Greater Tokyo	Core
13	**Tokyo**	Greater Tokyo	Core
14	**Kanagawa**	Greater Tokyo	Core
15	Niigata		
16	Toyama		
17	Ishikawa		
18	Fukui		
19	Yamanashi		
20	Nagano		
21	Gifu		
22	Sizuoka		
23	**Aichi**		Core
24	Mie		
25	Shiga		
26	**Kyoto**	Greater Osaka	Core
27	**Osaka**	Greater Osaka	Core
28	**Hyougo**	Greater Osaka	Core
29	Nara		
30	Wakayama		
31	Tottori		
32	Shimane		
33	Okayama		
34	Hiroshima		
35	Yamaguchi		
36	Tokushima		
37	Kagawa		
38	Ehime		
39	Kouchi		
40	Fukuoka		
41	Saga		
42	Nagasaki		
43	Kumamoto		
44	Oita		
45	Miyazaki		
46	Kagoshima		
47	Okinawa		

Table C: Gamma Distribution for all firms (single plant and multi-plant)

	1978			1980			1983			1985			1988			1990		
	σ	κ	μ	σ	κ	μ	σ	κ	μ	σ	κ	μ	σ	κ	μ	σ	κ	μ
Total	3.118	0.687	4.615	3.276	0.693	4.695	3.339	0.697	4.780	3.407	0.691	4.825	3.493	0.717	4.964	3.632	0.681	4.936
	*983.77***	*256.70***	*665.35***	*1023.24***	*258.20***	*642.07***	*1062.70***	*267.54***	*658.38***	*1075.36***	*266.98***	*655.81***	*1098.48***	*282.38***	*661.66***	*1137.10***	*270.16***	*644.98***
1	3.413	0.799	4.648	3.582	0.818	4.787	3.647	0.793	4.802	3.845	0.691	4.472	3.896	0.630	4.486	3.923	0.620	4.446
	*161.01***	*42.91***	*86.76***	*163.04***	*42.34***	*81.37***	*162.48***	*40.40***	*79.36***	*160.55***	*30.14***	*62.92***	*166.97***	*27.75***	*64.26***	*169.36***	*27.75***	*65.74***
2	3.122	0.607	4.113	3.293	0.787	4.337	3.332	0.837	4.640	3.393	0.782	4.580	3.619	0.893	4.734	3.600	0.782	4.556
	*74.08***	*14.00***	*39.41***	*76.95***	*20.99***	*42.67***	*77.68***	*22.59***	*44.3***	*77.32***	*20.33***	*41.9***	*80.55***	*23.32***	*39.51***	*84.08***	*21.39***	*41.47***
3	3.020	0.708	4.256	3.120	0.651	4.243	3.197	0.468	4.004	3.255	0.588	4.282	3.370	0.647	4.424	3.413	0.708	4.620
	*80.20***	*21.89***	*52.74***	*83.42***	*19.52***	*50.7***	*88.15***	*12.76***	*46.68***	*90.40***	*17.93***	*50.74***	*95.52***	*21.15***	*52.86***	*100.45***	*25.08***	*57.51***
4	3.016	0.640	4.440	3.191	0.754	4.680	3.245	0.644	4.523	3.286	0.603	4.433	3.535	0.778	4.763	3.559	0.623	4.579
	*99.85***	*24.40***	*69.22***	*104.99***	*30.24***	*69.55***	*108.79***	*24.83***	*66.48***	*109.85***	*23.11***	*65.57***	*118.64***	*32.34***	*66.23***	*120.43***	*24.98***	*64.17***
5	2.687	0.491	4.235	2.951	0.716	4.493	0.297	0.672	4.469	3.125	0.769	4.637	3.250	0.808	4.780	3.287	0.694	4.660
	*75.47***	*14.74***	*61.86***	*79.67***	*22.12***	*56.85***	*82.57***	*21.72***	*59.53***	*85.68***	*25.26***	*57.61***	*93.04***	*28.27***	*59.63***	*94.83***	*22.40***	*55.63***
6	2.878	0.636	4.353	2.883	0.679	4.624	2.965	0.665	4.667	3.005	0.612	4.655	3.076	0.658	4.870	3.145	0.573	4.861
	*95.38***	*23.91***	*70.14***	*94.67***	*25.85***	*73.71***	*98.90***	*25.75***	*74.04***	*101.49***	*23.84***	*74.66***	*105.65***	*27.38***	*79.06***	*110.04***	*23.05***	*77.37***
7	2.935	0.715	4.413	3.069	0.799	4.720	3.115	0.842	4.895	3.159	0.786	4.863	3.279	0.800	4.974	3.353	0.741	4.977
	*114.79***	*30.76***	*78.32***	*119.50***	*35.70***	*80.1***	*121.88***	*37.87***	*81.6***	*125.53***	*35.55***	*81.68***	*133.17***	*37.83***	*83.01***	*139.82***	*36.56***	*86.12***
8	3.120	0.752	4.526	3.341	0.809	4.674	3.346	0.720	4.639	3.570	0.827	4.853	3.664	0.738	4.753	3.860	0.722	4.745
	*132.91***	*36.98***	*84.76***	*142.93***	*40.88***	*82.19***	*151.49***	*37.58***	*86.4***	*157.53***	*43.85***	*83.04***	*165.76***	*39.63***	*82.27***	*174.35***	*39.48***	*79.95***
9	3.066	0.732	4.577	3.302	0.779	4.691	3.414	0.795	4.784	3.427	0.751	4.853	3.517	0.706	4.818	3.665	0.713	4.887
	*132.41***	*37.63***	*91.2***	*138.43***	*38.47***	*82.59***	*148.28***	*41.72***	*85.91***	*149.57***	*39.36***	*87.5***	*154.90***	*37.24***	*86.28***	*161.35***	*39.30***	*87.32***
10	3.036	0.684	4.603	3.138	0.647	4.651	3.234	0.729	4.883	3.396	0.857	5.132	3.429	0.816	5.159	3.622	0.832	5.250
	*141.05***	*36.95***	*98.84***	*146.10***	*34.08***	*95.98***	*153.15***	*41.94***	*102.64***	*159.71***	*51.68***	*104.23***	*165.02***	*50.47***	*106.89***	*172.13***	*51.85***	*103.76***
11	3.021	0.614	4.794	3.088	0.574	4.884	3.169	0.652	5.062	3.211	0.636	5.120	3.305	0.665	5.243	3.468	0.620	5.232
	*209.72***	*49.63***	*157.04***	*215.88***	*46.06***	*157.22***	*234.61***	*58.64***	*171.62***	*240.31***	*58.81***	*176.1***	*252.86***	*63.69***	*179.45***	*265.17***	*58.86***	*171.93***
12	3.453	0.716	4.433	3.662	0.704	4.439	3.628	0.750	4.725	3.675	0.707	4.729	3.927	0.771	4.823	4.112	0.773	4.850
	*154.07***	*37.85***	*81.23***	*159.98***	*36.35***	*75.41***	*165.90***	*41.47***	*84.81***	*168.15***	*39.38***	*85.52***	*180.79***	*44.84***	*83.34***	*183.53***	*43.84***	*78.24***
13	2.772	0.656	5.168	2.913	0.667	5.279	3.042	0.662	5.308	3.048	0.622	5.354	3.073	0.652	5.520	3.247	0.648	5.518
	*318.79***	*91.11***	*307.72***	*329.40***	*91.22***	*294.46***	*341.01***	*89.42***	*281.29***	*334.83***	*82.83***	*280.62***	*321.43***	*84.95***	*276.58***	*326.85***	*80.60***	*253.73***
14	3.197	0.786	5.084	3.244	0.696	5.089	3.212	0.748	5.306	3.291	0.747	5.365	3.376	0.772	5.529	3.502	0.727	5.543
	*192.83***	*57.21***	*135.43***	*196.87***	*50.92***	*136.92***	*206.08***	*60.46***	*155.47***	*210.50***	*60.82***	*154.74***	*217.70***	*64.07***	*156.27***	*224.61***	*60.36***	*152.53***
15	2.801	0.704	4.675	2.941	0.793	4.928	2.957	0.656	4.774	2.978	0.589	4.767	3.074	0.634	4.942	3.153	0.570	4.956
	*141.06***	*41.87***	*118.35***	*148.41***	*49.84***	*121.71***	*149.76***	*39.24***	*116.86***	*151.07***	*35.08***	*117.45***	*154.62***	*37.14***	*114.75***	*161.85***	*34.29***	*116.99***
16	2.973	0.699	4.578	3.092	0.657	4.625	3.050	0.653	4.795	3.097	0.609	4.818	3.231	0.704	5.062	3.418	0.677	5.000
	*94.83***	*26.49***	*69.95***	*97.32***	*22.77***	*64.04***	*101.50***	*25.33***	*74.04***	*103.42***	*23.75***	*74.34***	*108.93***	*29.06***	*76.48***	*114.23***	*28.09***	*72.78***
17	2.962	0.689	4.507	3.086	0.694	4.626	3.130	0.623	4.608	3.187	0.572	4.570	3.313	0.690	4.878	3.516	0.659	4.842
	*118.45***	*30.34***	*81.66***	*123.63***	*31.49***	*82.54***	*126.43***	*29.16***	*84.9***	*126.90***	*26.69***	*83.59***	*128.12***	*33.11***	*84.43***	*137.02***	*32.28***	*81.44***
18	2.867	0.611	4.495	3.091	0.622	4.564	3.086	0.499	4.528	3.223	0.633	4.706	3.240	0.570	4.781	3.354	0.560	4.879
	*99.15***	*23.59***	*74.88***	*102.44***	*21.61***	*64.5***	*108.26***	*18.62***	*71.15***	*109.17***	*24.69***	*70.11***	*107.95***	*22.22***	*71.93***	*112.25***	*21.78***	*70.62***
19	3.021	0.755	4.605	3.173	0.679	4.527	3.503	0.723	4.479	3.625	0.780	4.656	3.459	0.666	4.769	3.696	0.672	4.767
	*83.54***	*24.41***	*58.26***	*89.50***	*21.24***	*54.79***	*98.95***	*23.26***	*49.81***	*102.52***	*26.60***	*51.58***	*101.45***	*22.58***	*56.75***	*108.24***	*24.05***	*55.65***
20	2.944	0.642	4.532	3.079	0.664	4.657	3.190	0.639	4.665	3.142	0.588	4.799	3.230	0.559	4.856	3.342	0.544	4.913
	*142.92***	*36.20***	*106***	*148.65***	*37.65***	*103.91***	*157.44***	*37.29***	*104.64***	*157.16***	*34.97***	*111.71***	*159.12***	*32.08***	*107.38***	*165.51***	*32.16***	*108.13***
21	3.014	0.635	4.451	3.154	0.658	4.563	3.252	0.690	4.658	3.308	0.645	4.657	3.472	0.556	4.516	3.569	0.537	4.581
	*157.91***	*36.10***	*103.97***	*169.18***	*39.36***	*105.57***	*175.43***	*43.53***	*108.47***	*179.90***	*41.36***	*109.72***	*190.22***	*33.99***	*101.01***	*195.94***	*33.60***	*102.3***
22	3.001	0.686	4.686	3.159	0.679	4.745	3.253	0.716	4.865	3.252	0.709	4.992	3.333	0.720	5.137	3.430	0.673	5.132
	*192.70***	*50.90***	*139.63***	*203.33***	*50.88***	*136.17***	*214.44***	*56.66***	*141.23***	*217.40***	*59.05***	*150.95***	*223.84***	*61.04***	*153.03***	*230.72***	*57.57***	*151.7***
23	3.124	0.700	4.700	3.239	0.696	4.799	3.306	0.689	4.869	3.373	0.687	4.963	3.458	0.699	5.066	3.586	0.638	5.032
	*277.89***	*73.43***	*188.73***	*286.34***	*73.14***	*186.48***	*297.21***	*73.30***	*188***	*302.85***	*75.13***	*192***	*308.99***	*76.64***	*191.08***	*322.18***	*71.52***	*190.21***
24	3.188	0.765	4.449	3.432	0.825	4.625	3.473	0.819	4.727	3.542	0.695	4.480	3.696	0.648	4.390	3.854	0.637	4.352
	*126.45***	*35.81***	*77.59***	*131.88***	*37.51***	*71.2***	*138.10***	*38.74***	*74.79***	*142.18***	*32.80***	*72.87***	*148.60***	*30.34***	*69.24***	*154.82***	*30.86***	*68.76***
25	3.442	0.746	4.311	3.730	0.725	4.245	3.777	0.741	4.409	3.980	0.774	4.395	4.100	0.819	4.565	4.246	0.806	4.595
	*107.32***	*28.50***	*56.95***	*114.24***	*26.50***	*49.88***	*119.18***	*28.95***	*54.12***	*121.24***	*29.08***	*49.09***	*124.16***	*31.96***	*50.68***	*129.23***	*32.62***	*51.32***
26	3.258	0.658	4.595	3.396	0.656	4.643	3.350	0.749	4.998	3.407	0.655	4.833	3.528	0.681	4.952	3.560	0.635	4.965
	*168.05***	*38.77***	*101.54***	*171.50***	*37.55***	*96.24***	*172.04***	*45.97***	*108.1***	*172.17***	*39.21***	*103.23***	*173.23***	*40.26***	*99.91***	*173.22***	*37.63***	*100.45***
27	3.178	0.730	4.905	3.359	0.727	4.963	3.424	0.737	5.031	3.502	0.718	5.008	3.500	0.725	5.196	3.612	0.676	5.189
	*318.51***	*87.32***	*218.76***	*332.16***	*86.30***	*208.2***	*347.53***	*90.70***	*214.05***	*352.82***	*88.57***	*210.89***	*352.67***	*91.41***	*220.61***	*361.36***	*84.72***	*215.01***
28	3.246	0.677	4.462	3.498	0.688	4.478	3.580	0.717	4.584	3.701	0.698	4.510	3.724	0.694	4.603	3.964	0.683	4.524
	*210.40***	*51.32***	*127.03***	*221.36***	*51.10***	*116.03***	*228.92***	*54.46***	*117.13***	*231.71***	*51.55***	*110***	*234.57***	*53.02***	*115.15***	*246.67***	*52.74***	*108.06***
29	3.353	0.639	4.185	3.618	0.525	3.920	3.800	0.421	3.688	3.845	0.597	4.100	3.620	0.608	4.590	3.715	0.738	4.915
	*106.01***	*23.88***	*57.35***	*110.89***	*17.00***	*46.6***	*119.09***	*11.83***	*39.18***	*119.41***	*21.10***	*47.99***	*114.36***	*22.24***	*57.21***	*116.03***	*29.10***	*60.99***
30	3.212	0.692	4.372	3.413	0.693	4.360	3.323	0.711	4.621	3.356	0.745	4.812	3.502	0.620	4.461	3.684	0.590	4.376
	*99.20***	*24.62***	*58.75***	*102.60***	*24.48***	*54.99***	*104.17***	*27.09***	*63.51***	*102.63***	*27.89***	*63.38***	*106.99***	*22.89***	*58.53***	*111.28***	*21.63***	*54.85***
31	2.780	0.541	4.386	3.058	0.824	4.742	2.911	0.614	4.605	3.130	0.671	4.601	3.207	0.644	4.690	3.189	0.721	4.969
	*55.87***	*11.02***	*42***	*62.20***	*20.70***	*45.32***	*61.23***	*15.02***	*47.67***	*63.31***	*15.53***	*41.87***	*64.68***	*13.78***	*38.8***	*67.66***	*18.48***	*47.47***
32	2.672	0.589	4.407	2.817	0.432	4.210	2.798	0.392	4.257	3.063	0.534	4.347	3.064	0.506	4.494	3.167	0.478	4.512
	*64.81***	*16.72***	*57.84***	*69.19***	*11.16***	*52***	*70.88***	*10.47***	*55.37***	*75.47***	*14.15***	*48.85***	*76.55***	*13.40***	*50.65***	*78.29***	*11.59***	*46.27***
33	3.284	0.703	4.283	3.529	0.713	4.277	3.552	0.732	4.450	3.606	0.733	4.558	3.653	0.611	5.556	3.461	0.588	8.208
	*131.01***	*32.84***	*73.3***	*138.60***	*33.70***	*68.69***	*142.95***	*35.80***	*72.74***	*143.17***	*35.35***	*72.2***	*145.74***	*28.52***	*69.36***	*136.88***	*25.85***	*65.91***
34	3.084	0.733	4.677	3.261	0.763	4.813	3.241	0.800	5.020	3.350	0.783	5.021	3.409	0.750	5.088	3.507	0.638	5.006
	*141.40***	*40.38***	*99.28***	*147.41***	*41.80***	*95.27***	*151.22***	*45.50***	*102.55***	*154.12***	*44.46***	*99.43***	*156.80***	*42.52***	*98.99***	*163.07***	*36.24***	*97.97***
35	3.142	0.870	4.752	3.282	0.845	4.923	3.346	0.836	4.908	3.499	0.852	4.940	3.769	0.824	4.801	3.883	0.646	4.436
	*89.14***	*29.53***	*59.56***	*90.65***	*27.59***	*55.84***	*91.77***	*26.51***	*54***	*92.39***	*26.31***	*50.45***	*96.46***	*24.12***	*43.46***	*103.04***	*18.86***	*41.63***
36	0.292	0.601	4.217	3.174	0.672	4.303	3.260	0.626	4.253	3.298	0.576	4.239	3.260	0.531	4.340	3.394	0.624	4.534
	*79.31***	*19.17***	*56.92***	*82.36***	*20.02***	*49.93***	*89.40***	*20.51***	*53.17***	*87.73***	*17.18***	*48.89***	*89.03***	*16.36***	*52.7***	*90.63***	*19.95***	*52.81***
37	3.151	0.759	4.499	3.297	0.776	4.581	3.234	0.724	4.692	3.230	0.720	4.816	3.358	0.594	4.623	3.535	0.491	4.438
	*96.70***	*27.08***	*60.73***	*101.75***	*29.18***	*61.7***	*100.27***	*26.08***	*62.67***	*100.00***	*26.58***	*65.63***	*105.73***	*21.46***	*62.5***	*109.92***	*16.67***	*56.57***
38	3.187	0.584	4.102	3.364	0.704	4.407	3.466	0.669	4.320	3.505	0.677	4.474	3.538	0.750	4.707	3.711	0.693	4.554
	*105.45***	*20.50***	*57.59***	*109.66***	*26.59***	*59.68***	*116.83***	*26.32***	*59.99***	*117.92***	*27.43***	*62.33***	*117.78***	*31.24***	*64.91***	*123.68***	*29.07***	*61.75***
39	3.165	0.673	4.087	3.109	0.569	4.055	3.235	0.537	4.061	3.182	0.577	4.303	3.314	0.651	4.519	3.331	0.506	4.318
	*71.41***	*18.77***	*44.32***	*70.21***	*15.61***	*45.77***	*73.70***	*13.78***	*42.28***	*72.38***	*16.05***	*47.03***	*73.73***	*18.19***	*46.08***	*74.28***	*13.05***	*43.48***
40	2.937	0.851	4.990	3.112	0.797	4.971	3.143	0.854	5.181	3.362	0.927	5.283	3.473	0.917	5.340	3.500	0.719	4.996
	*139.11***	*47.65***	*109.75***	*146.34***	*44.81***	*104.71***	*148.42***	*49.24***	*109.31***	*152.98***	*52.34***	*100.68***	*159.75***	*52.99***	*100.82***	*163.23***	*40.81***	*97.27***
41	2.864	0.844	4.848	3.078	0.876	4.882	3.053	0.953	5.273	3.074	0.746	4.906	3.388	0.872	5.135	3.381	0.735	5.012
	*63.36***	*21.71***	*50.43***	*67.87***	*23.11***	*48.44***	*67.36***	*25.01***	*51.18***	*68.59***	*18.86***	*48.27***	*74.29***	*22.82***	*45.41***	*74.81***	*18.24***	*44.1***
42	2.766	0.787	4.631	2.895	0.677	4.543	3.019	0.714	4.610	3.048	0.727	4.683	3.183	0.710	4.705	3.248	0.666	4.652
	*71.93***	*23.85***	*59.81***	*76.38***	*20.31***	*57.04***	*80.59***	*21.73***	*55.98***	*81.99***	*22.79***	*57.62***	*84.85***	*22.20***	*55.28***	*87.91***	*21.51***	*56.36***
43	2.868	0.627	4.334	3.013	0.568	4.355	3.081	0.589	4.490	3.136	0.611	4.541	3.271	0.709	4.796	3.344	0.626	4.663
	*84.56***	*20.42***	*61.51***	*86.97***	*16.89***	*55.69***	*89.62***	*18.22***	*57.41***	*91.50***	*19.98***	*59.46***	*94.66***	*24.43***	*60.32***	*97.31***	*20.68***	*57.3***
44	3.101	0.829	4.623	3.226	0.775	4.550	3.290	0.851	4.824	3.217	0.888	5.043	3.423	0.994	5.320	3.197	0.730	7.113
	*76.10***	*24.17***	*50.56***	*78.70***	*22.54***	*48.81***	*78.04***	*24.06***	*47.95***	*76.21***	*25.64***	*51.79***	*78.81***	*28.16***	*49.28***	*78.21***	*20.90***	*48.54***
45	2.782	0.821	4.741	2.961	0.823	4.831	3.049	0.705	4.630	3.251	0.770	4.710	3.279	0.789	4.813	3.346	0.792	4.933
	*63.42***	*21.61***	*52.5***	*67.41***	*21.80***	*50.65***	*69.70***	*17.79***	*46.84***	*72.45***	*19.50***	*43.53***	*75.56***	*21.50***	*47.22***	*77.33***	*21.54***	*46.89***
46	3.200	0.649	4.026	3.384	0.691	4.045	3.328	0.612	4.141	3.490	0.646	4.174	3.565	0.605	4.221	3.638	0.680	4.446
	*94.03***	*21.77***	*52.52***	*98.32***	*23.97***	*51.42***	*98.87***	*21.22***	*54.53***	*101.38***	*22.70***	*52.18***	*101.49***	*20.47***	*50.45***	*102.65***	*23.42***	*51.17***
47	3.245	0.642	4.231	3.115	0.474	4.110	3.545	0.740	4.357	3.509	0.512	4.043	3.616	0.590	4.029	3.775	0.526	3.941
	*51.34***	*10.10***	*26.08***	*51.44***	*6.84***	*26.7***	*58.55***	*12.94***	*26.05***	*60.34***	*8.18***	*24.96***	*60.76***	*9.62***	*24.23***	*64.33***	*8.63***	*23.06***

**: significant at 5%
Bottom line in each estimate is z-value.