118th EAAE Seminar

"Rural development: governance, policy design and delivery"

Ljubljana, 25- 27 August 2010

SOURCES OF THE RURAL-URBAN PRODUCTIVITY DISPARITIES AND THE POLICY IMPLICATIONS ON RURAL DEVELOPMENT IN KOREA

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Paper prepared for presentation at the 118th seminar of the EAAE

(European Association of Agricultural Economists),

"Rural development: governance, policy design and delivery"

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ABSTRACT

This paper investigates the effect of trade cost changes on the spatial productivity distribution in Korea. Data on gross value added and primary factors for 163 spatial units during 2000-2005 are assembled to estimate local TFP using a value-added function. In our application, we control for agglomeration economies so as to identify factors shifting the regional raw-productivity distribution over time. The TFP estimation results show that the Korean regional economy exhibits constant returns to scale, along with significant localization economies. We find that and trade costs reduction and infrastructure improvement significantly shift to the right all percentile values of the regional productivity distribution, while amenity does not affect the movement of the distribution. An important policy implication of this study is that a country pursuing foreign market opportunities to boost economic growth and to raise incomes, like Korea, should also consider the consequent spatial realignment of resources. Also, productivity enhancements along with transfers to alleviate adjustments to trade-cost changes cannot be space blind.

Key words: agglomeration economies, spatial productivity distribution, trade cost,

JEL Classification: F1, R3

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Introduction

Spatial dispersion of economic activity in Korea is high with Seoul and its immediate neighborhood accounting for about 50% of GDP and employment. A number of authors have explored spatial variations in economic development across as well as within countries (Harrison, 1996; Frankel and Romer, 1999; Greenaway et al., 2002). The intra-country variations have become the centerpiece of the emerging literature on new economic geography (Krugman, 1991; Fujita et al., 1999; Baldwin et al., 2002). For instance, Henderson et al. (2001) find that rural regions' output, employment, and wages have persistently lagged behind that of their urban counterparts. Focusing on the sources of spatial inequalities, Rice et al. (2006) attribute most of the urban-rural income difference to that in productivity between the two regions. Hence, the question why we observe large inter-regional productivity differences takes on significance in policymakers' search for solutions to spatial inequality in economic development (Saito and Gopinath, 2009).

Simultaneously, research in international economics has identified the important role of trade costs in altering an industry's productivity distribution using micro-data (Bernard and Jensen, 1999; Helpman et al., 2004). Trade costs in this context refer to all factors limiting the movement of goods and services across countries, including handling and transportation costs, tariffs, and other barriers (Bernard et al., 2003). In an influential article, Melitz (2003) demonstrates the role of international trade as a catalyst for resource reallocation within an industry characterized by heterogeneous firms. More specifically, exposure to trade in a country induces not only its high-productivity firms to enter foreign markets but also its low-productivity firms to exit the domestic market. That is, declining trade costs alter an industry's extensive and intensive margins, namely the rate at which low-productivity firms die and high-productivity firms gain new resources, shifting the industry's productivity distribution to the right. The result is an increase in the industry's average productivity (Aw et al., 2000; Pavcnik, 2002; Bernard et al., 2007). Extending the above firm-heterogeneity models to the spatial dimension, Melitz and Ottaviano (2008) condition the productivity gains and intra-industry resource reallocation from competition on regional characteristics.

The objective of the present study is to investigate the impact of trade cost changes on the spatial productivity distribution in Korea. Changes in trade costs faced by the Korean economy, and the resulting impact on the productivity distribution have important consequences for resource allocation and regional economic development. The Korean economy has been opening up to international trade in recent decades, which has increased its competitiveness in the global economy (Koo and Lee, 2006). The Uruguay Round trade agreement, China's accession to WTO and recently negotiated bilateral free trade agreements have phased in trade reforms in other countries altering trade costs faced by Korean firms over the past decade. The additional trade exposure has been considered a boon to the Korean economy, but few studies have focused on the effects of trade reform on specific regions or states (Sohn et al., 2004; Lee and Zang, 1998; Lee, 1990).

The next three sections outline our research methodology to obtain measures of spatial productivity distribution employing data from micro units (Si or Gun, equivalent to a county or district in other countries). Then, we describe Kernel density techniques to capture the movements or shifts in the spatial productivity distribution followed by an empirical analysis of the sources of spatial variation in productivity. The final section provides a summary and conclusions.

Production-Function Approach

Agglomeration Economies and County (Si/Gun) Productivity

In this section, we describe a production-function methodology to estimate total factor productivity (TFP), while controlling for agglomeration economies. The latter allows us to quantify the raw productivity of each Si/Gun, and then identify factors which bring about changes or shifts in the regional raw-productivity distribution over time.

Beginning with Marshall, a number of authors have examined the nature and magnitude of agglomeration economies (see Henderson et al. 2001 for a survey). The economic geography literature explaining the spatial concentration of economic activities has relied on increasing returns to scale arising from technological spillovers, input-output linkages, and labor pooling. If average production costs decline as scale of production increases at the regional level, then it is beneficial to concentrate production in particular locations. Duranton and Puga (2004) examine three types of mechanism - sharing, matching and learning- which bring about such increasing returns. A firm located in close proximity to other firms in the same industry can take advantage of so-called localization economies. These intra-industry (sharing and learning) benefits include access to specialized know-how, the presence of industry-specific buyer-supplier networks, and opportunities for efficient subcontracting. Employees with industry-specific skills will be attracted to such clusters giving firms access to a larger specialized labor pool (matching).

Another source of agglomeration economies external to the firm point to benefits that accrue from being located in close proximity to firms in other industries, referred to as urbanization economies. These inter-industry benefits include easier access to complementary services, availability of a large pool with multiple specialization, inter-industry information transfers, and the availability of less costly general infrastructure (sharing, matching and learning). Localization and urbanization economies can be considered as centripetal or attractive forces leading to concentration of economic activities in specific locations. A number of centrifugal or repelling forces act in the opposite direction. These include increased costs resulting from higher wages driven by competition among firms for skilled labor, higher rents due to increased demand for housing and commercial land, and negative externalities such as congestion (Lall et al., 2004).

Following Henderson (2003) and others, we specify a Cobb-Douglas value-added function to distinguish the sources of agglomeration economies from raw TFP:

$$y_{it} = f(A_{it}) \; B_{it} \; K_{it} \; L_{it} \qquad (1)$$

where y_{it} is the output of the i-th spatial unit (Si/Gun) at time t, $f(A_{it})$ represents external influences on production from agglomeration economies, and B_{it} captures raw productivity (i.e. pure technology) effect, since the unit-specific agglomeration effects are already controlled by $f(A_{it})$. The Si or Gun is the basic political unit in Korea and the smallest spatial unit at which most economic data are available. The term B_{it} can be considered as an index of raw TFP, i.e., Hicks-neutral technical change. The variables $K$and L_{it} are i-th spatial unit's capital stock and labor at time t (Moomaw, 1983; Nakamura, 1985; Henderson, 1988).

The agglomeration economies are assumed to take an exponential form as follows:

where LQ_{it}^{j} a measure of localization economies, which can be computed using aggregate or industry (indexed by j) data and U_{it} is a measure of urbanization economies. Consistent with prior literature, the employment location quotient (LQ) is used to represent localization economies (Henderson, 2003). The LQ can capture disproportionately high concentration of an industry in a given region in comparison to the entire nation. For urbanization economies, we consider multiple indicators such as population density, employment density, and the industry diversity index (DI) which is the inverse of the often used Herfindahl-Hirschman Index (HHI). More details on the computation of the variables representing agglomeration economies are presented in the data section.

A double log production function is specified for the empirical analysis. Substituting (2) into (1), taking log, and then subtracting $\ln L_{it}$ from both sides yields:

$$\ln\left(\frac{y_{it}}{L_{it}}\right) = \ln B_{it} + \sum_{j=1}^{J} a_j LQ_{it}^{j} + bU_{it} + \alpha \ln\left(\frac{K_{it}}{L_{it}}\right) + (\alpha + \beta - 1)\ln L_{it} \qquad (3)$$

where $\rho = \alpha + \beta - 1$ represents the returns to scale. Since overall TFP (agglomeration effects + raw productivity) varies across Si/Guns and over years, the estimation of (3) should include fixed effects. We consider a two-way fixed effects specification with Si/Gun and time dummies:

d_{1p}, dt

where are respectively a Si/Gun- and year-specific intercept, respectively, and ε_{it} denotes a random disturbance term. As a result, the logarithm of raw TFP of Si/Gun i at year t is given as

$$\ln\widehat{B_{it}} = \ln\left(\frac{y_{it}}{L_{it}}\right) - \sum_{j=1}^{J} a_j LQ_{it}^{j} - bU_{it} - \alpha \ln\left(\frac{K_{it}}{L_{it}}\right) - \rho \ln L_{it} \qquad (5)$$

Then, we obtain the estimate of overall TFP level in the i-th Si/Gun at year t by

$$\ln\widehat{TFP_{it}} = \ln\left(\frac{y_{it}}{L_{it}}\right) - \alpha \ln\left(\frac{K_{it}}{L_{it}}\right) - \rho \ln L_{it} = \ln\widehat{B_{it}} + \ln\widehat{f(A_{it})} \qquad (6)$$

where $\ln\widehat{f(A_{it})} = \sum_{j=1}^{J} a_j LQ_{it}^{j} + bU_{1t}$ is the estimate of agglomeration effect in the i-th Si/Gun at year t.

Si/Gun Data

The Si or Gun is the basic political unit in Korea and the smallest spatial unit at which most economic data are available. Our data includes 163 spatial units (7 metropolitan cities, 76 Si and 80 Gun). Data on gross value added (GVA) during 2000 to 2005 are obtained from the Korea National Statistical Office for 7 metropolitan cities and 85 Si/Guns. Data on the remaining 71 Si/Guns data is not available now. We constructed data for these 71 Si/Guns using their share of local taxes in respective provinces as a proxy for their share of provincial GVA. That is, given provincial GVA, a Si/Gun's tax share is used to derive its GVA. For the 85 Si/Guns for which we have data, the correlation between the share of provincial taxes and that of provincial GVA in the sample period is very high (0.91).

In this study, the primary factors of production are capital, land and labor. Using the Census on Basic Characteristics of Establishment (Korea National Statistical Office) we proxy capital by the intangible fixed asset for mining and manufacturing firms at the end of year. Labor is given by employment in all industries. In the census, the employed persons for entire industries do not include agricultural workers. Thus, we add the number of agricultural workers to that of the employed persons in order to construct regional labor force of overall economy. Our final sample is a panel with four variables (GVA, capital, land and labor) for 163 spatial units during 2000-2005.

The empirical analysis employs alternative measures of agglomeration economies: location quotient (LQ), industry employment, industry establishments, population density, employment density, and the diversity index (DI) in a spatial unit (Henderson, 2003; Lall et al., 2004). The first three variables measure localization economies and the others measure urbanization economies in a given region. Among the former, the most often-used measure of industry (or sector) specialization in a given region is the employment location quotient (LQ) because employment in any industry is likely to be higher in dense areas and the average size of establishments might be smaller in areas where an industry concentrates. The employment-based LQ representing localization economies is defined as:

$$LQ_i^j = \frac{\frac{L_i^j}{L_i}}{\frac{L^j}{L}} \qquad (7)$$

where the superscript j refers to three groups of industries: traditional manufacturing industries (j=1), high-tech industries (j=2), and high-quality services (j=3)[1]. The subscript i refers to the spatial units. Hence L_i and L_i^j denote the overall employment of location i and that in sector j at location i, respectively. L^j and L denote the corresponding measures at the national level. The industrial employment data also come from the Census on Basic Characteristics of Establishment. For urbanization economies ($\mathbf{U_{it}}$), we use employment or population density, i.e. employed persons or residential population per square kilometer, of the spatial unit.

Estimation Results

In the empirical application, we consider alternative specifications of equation (4). First, we introduce arable land as another primary input representing regional resource endowment. The inclusion of arable land in the Cobb-Douglas production function changes equation (4) as[2]

However, the estimated coefficient on arable land is significantly negative, conflicting production theory. It seems that large proportion of Si/Guns located in rural areas, where per capita income is relatively low and arable land is relatively abundant, strongly affect the TFP estimation. Moreover, there is limited variation in the land data, which creates serious collinearity problems. Furthermore, the effect of arable land per capita on income per capita can be captured by province- or county (Si/Gun)- fixed effects. Thus, arable land does not seem to be a good proxy for regional resource endowment in our TFP estimation, so we drop the arable land in the production function. Second, we also estimate a traditional fixed effects model with two dimensions; Si/Gun and year. However, in this case, we have too many fixed effects (163 regions and 5 years) that they capture most of the per capita income differences across the spatial units, resulting in poor coefficients of per capita capital and labor (i.e., $\hat{\alpha}$ and $\hat{\rho}$)[3]. We infer this excessive fixed- effects specification is likely to attenuate the relationship between primary inputs and output based on the underlying production structure and therefore, we do not include it. Third, we also estimated the cross-Si/Gun TFP with a multiplicative functional form of agglomeration effects as;

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[1] The 1st industry group comprises electronic products, machinery, petro-chemistry, steel, shipbuilding, automobile, clothes and footwear. The 2nd sector includes semiconductor, mechatronics, IT, aerospace, biotechnology, nanotechnology, environment, precision instrument, and fine chemistry. The 3rd sector includes productive service (marketing, advertising, financial, etc), distribution, culture and tourist industry.

[2] The agglomeration effects are dropped to conserve space.

[3] With 163 region-fixed effects, $\hat{\alpha}$ is usually estimated as vanishingly small and $\hat{\rho}$ is estimated at about -0.5, implying large decreasing returns to scale, even though they are statistically significant. However, this fixed-effects modeling leads to considerable loss of degrees of freedom.

Some empirical works on testing mechanisms through which agglomeration economies influence productivity adopt this simple functional form[4]. However, estimation with the Si/Gun database for both functional forms reveals that the exponential function appears to be more appropriate than the multiplicative one in this application[5]. Finally, we consider some alternative variables representing agglomeration economies, such as location quotient (LQ), industry employment, industry establishments, population density, employment density, and the diversity index (DI) in a spatial unit. The first three variables measure localization economies and the others measure urbanization economies in a given region. With three industry-specific location quotients, each variable representing urbanization economies is alternatively chosen to estimate equation (4). Since the diversity index appears to be highly and negatively correlated with the location quotients, we focus on employment density and population density in our analysis.

Based on the above model-selection process, we consequently consider three basic specifications which are first estimated by OLS (Least Squares Dummy Variables, LSDV). The first one just includes two categorical dummies; nine provinces and five years[6]. The second model includes agglomeration effects with the same dummies. Here we use employment density in order to measure urbanization economies, since the inclusion of population density tends to greatly reduce the precision of estimates. Finally we drop employment density from the second specification. Table 1 shows the LSDV estimates of the three specifications.

Table 1. LSDV Estimates of the Value-Added Function with Si/Gun data

	Specification 1 (W/O Agglomeration effects)			Specification 2 (With Agglomeration effects)			Specification 3 (W/O Urbanization economies)		
	Coef.	t-value		Coef.	t-value		Coef.	t-value	
LQ1				**0.0468**	**3.60**	*******	**0.0470**	**3.62**	*******
LQ 2				**0.0690**	**7.53**	*******	**0.0692**	**7.55**	*******
LQ3				**0.3801**	**11.12**	*******	**0.3783**	**11.14**	*******
ED				**-0.000008**	**-0.49**				
ln(K/L)	**0.1262**	**16.89**	*******	**0.1026**	**10.61**	*******	**0.1034**	**10.83**	*******
lnL	**0.0694**	**6.63**	*******	**0.0115**	**0.89**		**0.0081**	**0.74**	
P1	2.4303	20.83	***	2.6833	21.14	***	2.7141	24.53	***
P2	2.3647	22.19	***	2.7026	21.71	***	2.7370	26.5	***
P3	2.3718	21.36	***	2.7349	21.43	***	2.7684	25.64	***
P4	2.3261	20.62	***	2.6965	20.65	***	2.7316	24.94	***
P5	1.9446	17.47	***	2.3337	18.07	***	2.3683	21.84	***
P6	2.1170	19.15	***	2.5004	19.46	***	2.5351	23.57	***
P7	2.1850	19.75	***	2.5653	19.90	***	2.6003	24.13	***
P8	2.2892	20.12	***	2.6690	20.35	***	2.7039	24.48	***
P9	2.1683	14.97	***	2.5495	15.89	***	2.5896	18.72	***
2001	0.0245	0.82		0.0174	0.63		0.0173	0.63	
2002	0.0631	2.12	**	0.0633	2.29	**	0.0631	2.29	**
2003	0.1057	3.55	***	0.1078	3.91	***	0.1075	3.90	***
2004	0.1535	5.16	***	0.1516	5.50	***	0.1513	5.49	***
2005	0.1760	5.91	***	0.1740	6.31	***	0.1737	6.30	***
	Log- Likelihood = -94.3937			Log- Likelihood = -17.4479			Log- Likelihood = -17.5725		

*** indicate significance at 1% level; ** indicates significance at 5% level.
Dependent variable : Log of Value-Added per worker, 2000-2005

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[4] Henderson (2003) and Lall et al. (2004) assume a multiplicative functional form.

[5] To conserve space, we do not report the result of TFP estimation for the multiplicative agglomeration function.

[6] We drop the first year (2000) dummy in order to avoid perfect multicollinearity.

Without considering agglomeration effects, the basic model with 14 dummies reveals that the overall industry exhibits marginally increasing returns to scale ($\rho = 0.0694$) . With the agglomeration effects, the increasing returns to scales disappear and the regional economy exhibits constant returns to scale. Thus, the increasing returns seem to be attributed to agglomeration economies, in particular, to localization economies. All the coefficients of location quotients are significant and positive, but there are no significant effects of urbanization economies. While there are numerous benefits to firms being located in large urban centers, these economies can be offset by costs such as increases in land rents and wage rates as well as commuting times for workers. In fact, most manufacturing activities cannot afford the cost of wages and rents in large metropolitan areas (Henderson et al., 2001). The net effect of urbanization economies on economic productivity is an empirical question (Lall et al., 2004).

The estimation results without considering urbanization economies are presented in the third column. The overall Si/Gun economy still exhibits constant returns to scale and the benefits of localization economies do not change much. The estimates for location quotients support positive intra-sector externalities, especially, in the high-quality service sector. We choose the third specification based on likelihood-ratio (LR) test against the other two specifications. However, the great variances of regressors among the spatial units imply the potential presence of systematic heteroscedasticity. That is, the disturbance variance is likely to vary with a set of regressors. Thus, we conduct the Breusch-Pagan Lagrange multiplier (LM) test for heteroscedasticity. The LM statistics is 259.07, which is larger than the critical value, so the hypothesis of homoscedasticity is rejected[7]. Having tested for and found evidence of heteroscedasticity, we chose the weighted-least squares (WLS) technique to correct for it. The WLS estimates are presented in Table 2. Based on the coefficients in table 2, we calculate the logarithm of raw TFP, overall TFP, and agglomeration effects for each observation based on equations (5) and (6).

Table 2. WLS Estimates of the Value-Added Function with Si/Gun data

	Coef.	t-value			Coef.	t-value			Coef.	t-value	
LQ1	**0.0283**	**2.57**	**	P1	2.8197	32.18	***	2001	-0.0179	-0.93	
LQ 2	**0.0466**	**6.90**	***	P2	2.7944	33.07	***	2002	0.0255	1.31	
LQ3	**0.3235**	**8.82**	***	P3	2.8367	32.80	***	2003	0.0446	2.11	**
ln(K/L)	**0.1295**	**15.04**	***	P4	2.7844	31.80	***	2004	0.0970	4.43	***
lnL	**0.0059**	**0.63**		P5	2.4492	27.32	***	2005	0.1189	5.48	***
				P6	2.5971	29.29	***				
				P7	2.6758	30.12	***				
				P8	2.8159	31.15	***				
				P9	2.6847	27.35	***				

Log- Likelihood = 248.838, Obs. = 958

*** indicate significance at 1% level; ** indicates significance at 5% level.
Dependent variable : Log of Value-Added per worker, 2000-2005

Kernel Density Plots of Spatial Productivity Distribution

With the estimated raw TFP levels of Si/Guns from above, we first approximate the spatial productivity distribution for each year by using a nonparametric kernel density estimator. For this purpose, we group all the Si/Guns into 4 extended regions[8]. Such a grouping allows us to estimate 24 kernel densities of raw productivity (4 regions × 6 years) in the empirical analysis. As a nonparametric

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[7] The 95 percent critical value of Chi-squared distribution with 19 degrees of freedom is 30.14.

[8] The first extended region (ER1) represents national primacy and main economic center. The second extended region (ER2) includes surroundings of the first extended region. The third extended region (ER3) is comprised of relatively rural and remote areas. The fourth extended region (ER4) is located in southeastern coastal area and is relatively specialized in traditional manufacturing industries. The second biggest city, Busan also play a role as a regional economic center in the fourth region.

approach, kernel density estimators have no fixed structure and depend upon all the data points to derive an estimate. Specifically, a kernel function is centered at each estimating point. A spatial unit's contribution to the density estimation at some estimating point depends on how far the spatial unit's productivity is apart from that point. As a result, kernel functions yield a smooth estimation of the distribution curve (Beaudry et al., 2005; Jones, 1997).

Kernel estimation requires choices of kernel type and kernel width. In particular, if we smooth too much, we throw away detail that might be informative, while if we smooth too little, we might be distracted by detail that is not informative. Here, densities are computed using a Gaussian kernel at each estimating point. We follow the convention in the literature to use the bandwidth, $w = 1.059\sigma n^{\frac{1}{5}}$, where σ is the standard deviation of logarithm of TFP, and n is the number of observations. However, the kernel estimator suffers from a slight drawback when it is applied to long-tailed distributions. Because the bandwidth is fixed across the entire sample, there is a tendency for spurious noise to appear in the tails of the estimates; if the estimates are smoothed sufficiently to deal with this, then essential detail in the main part of the distribution is masked (Silverman 1986)[9]. To avoid this kind of estimation bias, we should remove one or two outliers from each sample in our application[10]. Cumulative density then allows estimation of alternative percentile values (10th percentile, median, and 90th percentile), and first and second moments of the distribution.

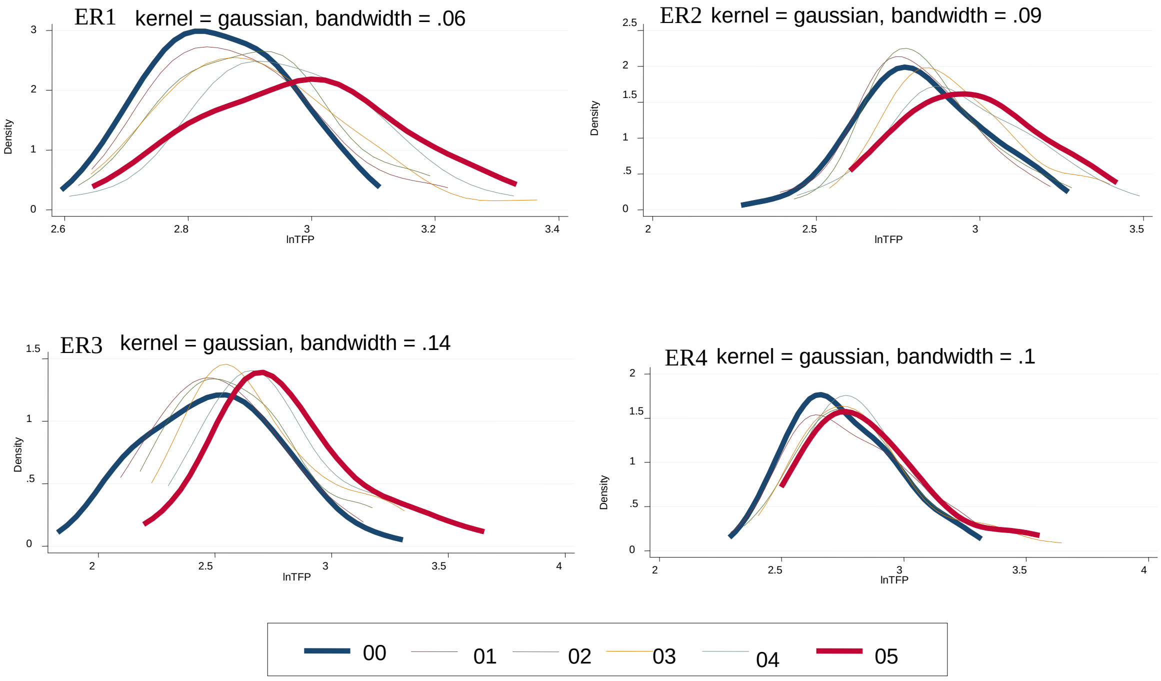

Figure1. Kernel density estimate for 4 extended regions

Table 3. Descriptive Statistics, 2000 and 2005:Mean and Standard Deviation of (log) raw TFP distribution for each region

Extended Region	Obs.	2000		2005		Annual growth rate (%)
		Mean	S.D.	Mean	S.D.	
ER1	33	2.866	0.138	2.995	0.171	0.89
ER2	45	2.848	0.220	3.001	0.235	1.05

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[9] In the case of long-tailed distributions, a fixed bandwidth approach may result in under-smoothing in areas with only sparse observations while over-smoothing in others.

[10] Each sample has a relatively small number of observations. The adaptive kernel method using a varying, rather than fixed, bandwidth can be employed instead, however basically because of the small number of sample, it does not largely improve the problem.

ER3	39	2.515	0.312	2.820	0.321	2.32
ER4	46	2.765	0.229	2.883	0.307	0.84

Figure 1 shows the estimated kernel density curves for each of the four extended regions during 2000 to 2005. Also, table 3 presents the mean and standard deviation of each extended region's raw productivity distribution in the same years. All extended regions have experienced positive productivity growth during 2000 to 2005, and average annual growth rate varies between 0.84 and 2.32. Note that the relatively remote and less-developed region(ER3) has considerably improved its raw productivity during the period; the regional raw productivity of ER3 has grown over twice as much as those of others have grown.

Sources of Spatial Variation in Korean Productivity

Now we turn to the main question of this study; has the increased exposure to international trade affected the spatial distribution of productivity in Korea (Melitz, 2003; Syverson, 2004; Bernard et al., 2007; Melitz and Ottaviano, 2008)? How much does the change of trade costs shift the productivity distributions to the right? Recent firm-heterogeneity trade literature says that trade liberalization shifts the mean of the productivity distribution to the right, resulting in higher average industry productivity (Melitz, 2003). The latter is due to the truncation from below of the productivity distribution, which forces the least productive firms to exit the industry (Syverson, 2004).

To empirically identify the effect of trade liberalization on the industry's productivity distribution, we specify the estimated first moment and alternative percentile values as a function of a measure of trade liberalization (Amiti and Konings, 2007). Note that we already controlled out the agglomeration effects on the productivity of each local unit (Si/Gun). However, there may be some other factors which also shift the productivity distribution. Except trade cost which is common to all extended regions, the level of infrastructure and amenities in each extended region likely affect the spatial distribution of raw productivity. A spatial unit (Si/Gun) located in the extended region having well developed infrastructure could be more efficient in production due to easier market access or lower transport cost than the one located in a poor-infrastructure region, if the distance from market is assumed to be the same for both of them. In this context, infrastructure is considered to be the accumulated physical capital for the extended regions beyond the industrial capital stock directly used in production. Ceteris paribus, a location in the region with higher level of amenities is more attractive to firms and labors compared to that in low-amenity region, too. Some amenities may also enhance productivity. For example, while a lack of severe snowstorms is an amenity, it may also increase productivity because blizzards can be costly to firms (Wu and Gopinath, 2008). Thus, we consider infrastructure and amenities as well as trade cost as the major contributing factors, which determine the movement of raw productivity distribution across extended regions and over years.

According to the alternative percentile values, we can partition the raw panel into three groups. Then, we specify the group-wised estimated TFP values as a function of trade cost, infrastructure, and amenities.

$$\mathbf{ln}\widehat{\mathbf{TFP}}^{\mathbf{p}}_{\mathbf{et}} = \mathbf{g}^{\mathbf{p}}(\mathbf{TC}_{\mathbf{t}}, \mathbf{Infra}_{\mathbf{et}}, \mathbf{AM}_{\mathbf{et}}) \tag{10}$$

where the superscript p refers to three alternative percentiles(10%, 50%, 90%), implying three different estimation functions, and the subscripts e and t refers to the four extended regions and years during 2000 to 2005, respectively. Note that the estimation equation of (10) cannot include time fixed effects but only regional fixed effects, because the explanatory variable, trade cost is only time-variant. Thus, equation (10) is estimated with regional fixed effects as

δ_1^p

The estimated coefficient , for example, represents the effect of trade cost change on the shift of productivity distribution for each alternative percentile group. The computation of trade costs follows Novy's (2008) approach, which does not impose any trade cost function that uses distance, borders barriers or other trade cost proxies. Novy (2008) suggests making use of international trade flows to express multilateral resistance terms as a function of observable trade and output data. His basic idea is that bilateral trade costs affect trade flow in both directions

x_{ij}, x_{ii},

( ) and intra-national trade ( ) can be used as a size variable that controls for multilateral resistance. Since gross bilateral trade cost factor between i and j are

$t_{ij} =$

symmetric ( ), bilateral trade costs (τ_{ij}) _((_ _)/(_ _))^(

$$\tau_{ij} = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2(\sigma-1)}} - 1 \qquad (12)$$

Here it should be noticed that the trade costs calculated in this way capture not only traditional trade costs, e.g. transportation costs and tariff, but also non-tariff barriers (language/cultural barrier). For computation of trade costs as equation (12), we consider GDP excluding service sector as intra-national trade. GDP data trade data of Korea and its major trading partner countries (China, US, Japan, and Taiwan) are obtained from the Bank of Korea and World Bank. Bilateral trade cost estimates with four major trading partners are reported in Table 4 over the period 2000-2005. Outbound and inbound trade costs are assumed to be symmetric, which means that as trade costs fall, there are more opportunities in the export markets as well as greater foreign competition within the domestic market. The tariff-equivalent trade costs with China and U.S., for example, considerably declined from 0.41 to 0.22, and slightly increased 0.38 to 0.39, respectively. The average change in trade cost with four major partners, weighted by countries' respective trade volumes with Korea, declined 24.5% over the six years with the annual growth rate is -5.47%. For estimation purpose, we define the freeness of trade (FT) as the inverse of the weighted average trade costs so that FT increased during the same period, as shown in the last column of table 4.

Table 4. Estimates of Korea's Bilateral Trade Costs during 2000 to 2005

Year	Tariff equivalent, τ_{ij} (%)					Freeness of trade
	Korea -U.S.	Korea -Japan	Korea -China	Korea -Taiwan	Weighted average	
2000	0.38	0.40	0.41	0.50	0.40	2.48
2001	0.43	0.42	0.42	0.54	0.43	2.32
2002	0.44	0.42	0.38	0.53	0.42	2.36
2003	0.43	0.38	0.32	0.49	0.38	2.61
2004	0.36	0.30	0.22	0.39	0.30	3.33
2005	0.39	0.31	0.22	0.40	0.30	3.28

Percentage Change (%)	2.23	-21.35	-47.79	-19.15	-24.53	32.50
Annual growth rate(%)	0.44	-4.69	-12.19	-4.16	-5.47	5.79

We use the density of paved roads (unit:$\frac{\mathbf{km}}{\mathbf{km^2}}$) as the indicator of infrastructure level for each extended region. We calculate it in line with the division of four extended regions. The indicators representing the level of amenities for each extended region would be climate variables such as mean air temperature ($\mathbf{C^0}$), clear days, and precipitation (mm), and natural environment variables such park-, forest-, and river- area densities[11]. Table 5 presents all those variables used in our empirical application. The average annual growth rate of road density varies between 2.4 and 3.8. However, amenity variables, except for clear days and park area density, usually do not much change over time.

Based on equation (11), we consider four alternative specifications which are estimated using the OLS estimator. The empirical models include the freeness of trade instead of trade costs as follows;

$$\mathbf{ln\widehat{TFP}^p_{et} = d^p_e + \delta^p_1 FT_t + \delta^p_2 Infra_{et} + \delta^p_3 AM_{et} + \varepsilon_{et}} \qquad \mathbf{(13)}$$

Model 1 employs log-linear functional form without amenity in the right hand side of equation (13). Model 2 is the same as equation (13) having an amenity variable as one of regressors. Model 3 and 4 differ from Model 1 and 2, respectively, in that they include an interaction term between infrastructure and freeness of trade. These models are applied to three different samples separated by alternative percentiles of the kernel densities. The estimation results are reported in tables 6 for four alternative specifications. The first column shows the parameter estimates obtained with 10th percentile sample. So do the second and the third columns with median and 90th percentile samples, respectively.

Table 5. Infrastructure and Amenities for four extended regions during 2000 to 2005

	2000	2001	2002	2003	2004	2005	Annual growth rate (%)
Infrastructure ($\frac{\mathbf{km}}{\mathbf{km^2}}$)							
ER1	1.59	1.66	1.69	1.69	1.72	1.79	2.40
ER2	0.47	0.48	0.53	0.53	0.55	0.55	3.33
ER3	0.74	0.77	0.82	0.83	0.86	0.89	3.78
ER4	0.60	0.64	0.66	0.67	0.69	0.71	3.21
Mean air temperature (℃)							
ER1	12.6	12.6	12.6	12.5	13.0	12.0	-0.86
ER2	12.0	12.4	12.4	12.2	13.1	12.0	-0.02
ER3	14.5	14.8	14.7	14.5	15.1	14.2	-0.32
ER4	14.0	14.4	14.0	13.8	14.7	13.7	-0.53
Precipitation (㎜)							
ER1	1225.0	1199.2	1217.8	1743.0	1341.2	1314.0	1.41
ER2	1365.1	946.9	1450.7	1750.9	1475.2	1386.2	0.31
ER3	1418.1	1171.2	1454.2	1925.5	1557.9	1250.5	-2.48
ER4	1172.2	1038.3	1570.0	1975.5	1350.7	1149.2	-0.40
Clear days (days)							
ER1	98.3	103.7	106.0	92.3	121.0	125.0	4.92

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[11] USDA's Economic Research Service developed a county-level natural amenity based on six factors (McGranahan, 1999): warm winter (average January temperature), winter sun (average number of sunny days in January), temperate summer (low winter-summer temperature gap), summer humidity (low average July humidity), topographic variation (topography scale), and water area (water area proportion of county area).

ER2	81.2	81.3	88.7	77.4	103.3	103.6	4.99
ER3	88.2	67.1	65.1	62.6	92.6	69.4	-4.66
ER4	113.6	108.5	111.7	91.1	131.1	130.3	2.78
park/area ($\frac{\mathbf{km}^2}{\mathbf{km}^2}$)							
ER1	0.0261	0.0267	0.0272	0.0288	0.0319	0.0290	2.18
ER2	0.0059	0.0060	0.0064	0.0065	0.0068	0.0074	4.69
ER3	0.0098	0.0082	0.0078	0.0079	0.0083	0.0083	-3.19
ER4	0.0112	0.0113	0.0114	0.0111	0.0116	0.0123	1.95
forestry/area ($\frac{\mathbf{km}^2}{\mathbf{km}^2}$)							
ER1	0.5364	0.5337	0.5315	0.5294	0.5273	0.5257	-0.40
ER2	0.7110	0.7103	0.7095	0.7089	0.7083	0.7077	-0.09
ER3	0.5745	0.5736	0.5717	0.5708	0.5701	0.5686	-0.21
ER4	0.6962	0.6957	0.6952	0.6948	0.6944	0.6937	-0.07
river/area ($\frac{\mathbf{km}^2}{\mathbf{km}^2}$)							
ER1	0.0390	0.0389	0.0390	0.0388	0.0388	0.0389	-0.06
ER2	0.0253	0.0252	0.0252	0.0251	0.0251	0.0252	-0.07
ER3	0.0236	0.0236	0.0236	0.0236	0.0236	0.0236	0.02
ER4	0.0305	0.0304	0.0304	0.0304	0.0304	0.0304	-0.04

Table 6. The Source of Variation in the Spatial Distribution of TFP (raw productivity)

	10 percentile			Median			90 percentile		
	Coef.	t-value		Coef.	t-value		Coef.	t-value	
(S1-W/O interaction term and amenity)									
Infra	0.7637	2.77	**	0.7142	3.61	***	1.4396	4.13	***
FT	0.0561	1.86	*	0.0738	3.4	***	0.0625	1.63	
ER1	-0.5691	-2	*	-0.6046	-2.97	***	-1.5313	-4.26	***
ER2	0.2271	4.89	***	0.1965	5.9	***	0.2160	3.68	***
ER3	-0.3529	-7.08	***	-0.2857	-8	***	-0.3207	-5.09	***
Cons	1.8490	13.57	***	2.1054	21.56	***	2.0515	11.9	***
Adjusted R^2		0.946			0.950			0.759	
Log-Likelihood		45.138			53.131			39.496	
(S2-W/O interaction term)									
Infra	0.7983	2.7	**	0.6962	3.27	***	1.4379	3.82	***
FT	0.0524	1.62		0.0757	3.25	***	0.0626	1.52	
Temp	0.0113	0.39		-0.0059	-0.28		-0.0006	-0.02	
ER1	-0.5871	-1.99	*	-0.5953	-2.81	**	-1.5304	-4.09	***
ER2	0.2518	3.19	***	0.1837	3.23	***	0.2148	2.14	**
ER3	-0.3643	-6.19	***	-0.2798	-6.62	***	-0.3201	-4.28	***
Cons	1.6768	3.64	***	2.1947	6.63	***	2.0604	3.52	***
Adjusted R^2		0.943			0.947			0.745	
Log-Likelihood		45.246			53.187			39.497	
(S3-W/O amenity)									
Infra	1.1112	3.66	***	0.9301	4.14	***	1.7657	4.35	***
FT	0.1301	2.88	**	0.1197	3.59	***	0.1318	2.19	**
Infra×FT	-0.0877	-2.08	*	-0.0545	-1.75	*	-0.0823	-1.46	
ER1	-0.6796	-2.55	**	-0.6733	-3.42	***	-1.6350	-4.6	***
ER2	0.2425	5.59	***	0.2060	6.43	***	0.2305	3.98	***
ER3	-0.3693	-7.95	***	-0.2960	-8.62	***	-0.3362	-5.42	***
Cons	1.5764	8.69	***	1.9360	14.44	***	1.7959	7.41	***

Adjusted R^2		0.955			0.955			0.773	
Log-Likelihood		47.850			55.110			40.911	
(S4-With interaction term and amenity)									
Infra	1.1235	3.52	***	0.9073	3.88	***	1.7508	4.11	***
FT	0.1275	2.64	**	0.1245	3.51	***	0.1349	2.09	*
Infra×FT	-0.0867	-1.98	*	-0.0563	-1.75	*	-0.0834	-1.43	
Temp	0.0053	0.2		-0.0098	-0.5		-0.0064	-0.18	
ER1	-0.6868	-2.48	**	-0.6600	-3.25	***	-1.6263	-4.4	***
ER2	0.2538	3.48	***	0.1850	3.45	***	0.2167	2.22	**
ER3	-0.3745	-6.86	***	-0.2864	-7.15	***	-0.3299	-4.53	***
Cons	1.4991	3.44	***	2.0794	6.51	***	1.8894	3.25	***
Adjusted R^2		0.952			0.953			0.759	
Log-Likelihood		47.879			55.293			40.935	

***, **, and * indicate significance at 1%, 5%, and 10% level, respectively.

The results from all four models (as well as all three samples) are generally consistent in that the coefficients of infrastructure and freeness of trade are statistically significant at less than 10% level and have positive signs consistent with economic theory. However, in most cases, amenity variable is not significant, implying that it does not affect the spatial distribution of productivity in Korea[12]. Note that for each region amenity variables are usually constant over time so appear to serve as region-specific fixed effects, causing multicollinearity problem. Moreover, amenity variables are measured over the very broadly extended areas so that they might not reflect their productivity-enhancing characteristic in a narrowly defined region.

The interaction term is not significant in the fourth specification, while it is significant at 10% level in the model without amenity, only for 10th percentile and median samples. In both cases, the sign is unexpectedly negative, implying that the marginal effect of freeness of trade on productivity is increased when infrastructure is less developed and also that the marginal effect of infrastructure on productivity increase when trade is less liberalized[13].

According to the LR specification tests among four models, the first model (S1-W/O interaction term and amenity) is chosen to quantify the effect of trade liberation on the spatial distribution of productivity and to compare the magnitude of the effect among different percentile samples. Since the dependant variable is the logarithm of TFP, basically all specifications are semi-log equations, so the coefficients are partial- or semi-elasticities[14]. For example, the infrastructure slope estimate 0.7637 means that, in the case of low productive Si/Guns, productivity (TFP) increases 0.76% in response to every additional 0.01 point increase of paved road density (unit:). In the same way, for the low productive Si/Guns, the additional 0.01 point increase of freeness of trade induces 0.056 % increase of raw productivity. The semi-elasticity of percentile TFP with respect to infrastructure is highest in high productive Si/Guns (1.4396) and the semi-elasticity with respect to freeness of trade is highest in median percentile Si/Gun group (0.0738). Additionally, comparing the other two percentile group (10th vs. 90th) implies that productivity improvement induced by more liberalized trade is slightly faster in high productive local regions than in low productive ones (0.0625 > 0.0561). Meanwhile, the dummy variable coefficients imply that the raw productivity of the first extended region (ER1), which is an economic center or metropolitan area, is much less than that of ER4 and ER2 which are relatively specialized in manufacturing industries. This pattern increases with the increase of alternative percentiles ($d_1^{10\%}$ = -0.5691, $d_1^{50\%}$ = -0.6046, $d_1^{90\%}$ = -1.5313), suggesting that locating in highly urbanized area tends to have a more negative effect on raw productivity in high-productivity Si/Guns

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[12] We repeated the estimations for six different amenity variables. Table 6 only presents the result with average temperature. The results with other amenity variables are not reported. They are similar to the case of temperature.

[13] We infer that there is a trade-off relationship between domestic infrastructure and trade liberalization in their enhancing productivity.

[14] We can interpret each coefficient $\hat{\beta}$ as $\%\Delta y = (100\hat{\beta})\Delta x$, where *y* and *x* are dependent and independent variables, respectively

than in their low-productivity counterparts. Finally, without the interaction term, the effect of trade costs reduction on the spatial distribution of raw productivity is directly evaluated by estimating the first specification with trade costs instead of the fitness of trade variable. Table 7 presents the estimation results, showing that the negative effects of trade costs effect are more precisely estimated in all percentile groups and the overall results are much similar with the previous results.

Table 7. The Effects of Trade Cost Changes on TFP (raw productivity)

	10 percentile			Median			90 percentile		
	Coef.	t-value		Coef.	t-value		Coef.	t-value	
Infra	0.7624	2.8	**	0.7157	3.68	***	1.4190	4.15	***
TC	-0.4460	-1.9	*	-0.5824	-3.48	***	-0.5193	-1.76	*
ER1	-0.5678	-2.02	*	-0.6062	-3.03	***	-1.5101	-4.28	***
ER2	0.2269	4.93	***	0.1967	5.99	***	0.2131	3.69	***
ER3	-0.3527	-7.15	***	-0.2860	-8.13	***	-0.3175	-5.12	***
Cons	2.1701	8.62	***	2.5238	14.05	***	2.4302	7.68	***
Adjusted R^2		0.9465			0.951			0.7638	
Log-Likelihood		45.135			53.161			40.116	

***, **, and * indicate significance at 1%, 5%, and 10% level, respectively.

Using the estimates in table 7, we obtain the elasticity of infrastructure and that of trade costs with respect to the alternative percentile TFP, respectively. The overall average elaticities and the counterparts for each extended region are given in table 8. The average elasticity of productivity with respect to infrastructure ranges from 0.235 to 0.418. One percent rise of infrastructure index enhances average regional productivity in Korea by 0.235 percent at 1% significance level, confirming the crucial role of infrastructure in regional productivity growth. The raw productivity-improvement effect of infrastructure is stronger for the high-productivity spatial units. Among the extended regions, the TFP of the most urbanized area, ER1 appears to be almost twice elastic to infrastructure improvement as do those of other extended regions.

Again, trade costs reduction shifts the spatial distribution of raw TFP to the right significantly, with elasticities ranging from 0.062 to 0.079. Compared with infrastructure effect, the reduction of trade costs more evenly affects local productivity among the extended regions as well as the alternative percentile groups. Note that the median TFP group responds to more liberalized trade the most, but responds to improved infrastructure the smallest among alternative percentile groups. It is also shown that Si/Guns in the remotest region, ER3 have experienced productivity enhancement caused by trade costs reduction the most.

Table 8. The Average Elasticities of TFP with respect to Infrastructure and Trade Costs

	10 percentile		Median		90 percentile	
Elasticity of TFP with respect to Infrastructure						
Average	0.275	(0.0256)	0.235	(0.0229)	0.418	(0.0435)
ER1	0.473	(0.0061)	0.415	(0.0040)	0.767	(0.0052)
ER2	0.151	(0.0028)	0.129	(0.0025)	0.231	(0.0039)
ER3	0.274	(0.0020)	0.225	(0.0031)	0.377	(0.0038)
ER4	0.201	(0.0035)	0.170	(0.0031)	0.296	(0.0050)
Elasticity of TFP with respect to Trade costs						
Average	-0.067	(0.0025)	-0.079	(0.0027)	-0.062	(0.0022)
ER1	-0.061	(0.0041)	-0.075	(0.0052)	-0.063	(0.0044)
ER2	-0.064	(0.0045)	-0.076	(0.0055)	-0.061	(0.0046)
ER3	-0.074	(0.0060)	-0.084	(0.0066)	-0.064	(0.0053)
ER4	-0.067	(0.0047)	-0.079	(0.0053)	-0.061	(0.0041)

Numbers in parentheses are standard deviations.

Summary and Conclusions

This paper investigates the effect of trade cost changes on the spatial productivity distribution in Korea. Data on gross value added and primary factors for 163 spatial units during 2000-2005 are assembled to estimate local TFP using a value-added function. In our application, we control for agglomeration economies so as to identify factors shifting the regional raw-productivity distribution over time. The TFP estimation results show that the Korean regional economy exhibits constant returns to scale, along with significant localization economies.

We then regroup the spatial units into four extended regions within the Korean economy. For each extended region, we approximate the spatial productivity distribution in each year by a smoothing kernel density estimation. Cumulative density then allows estimation of the first and second moments of the regional productivity distribution as well as alternative percentile values (10th percentile, median, and 90th percentile). The latter are used to represent shifts of the spatial productivity distribution over time.

To identify the sources of spatial variation in productivity, we specify the estimated first moment and alternative percentile values as a function of a measure of trade liberalization, while controlling for the role of infrastructure and climatic differences. We find that and trade costs reduction and infrastructure improvement significantly shift to the right all percentile values of the regional productivity distribution, while amenity does not affect the movement of the distribution. The results are consistent with the key prediction of firm-heterogeneity trade models, saying that trade liberalization eliminates the least productive firms in an industry, resulting in higher average industry productivity. Even though these models are more appropriate for firm-level data, our regional aggregate data do not contradict their main results, since the shift of spatial productivity distribution likely reflects the underlying resource reallocation from low-productivity firms toward high-productivity ones induced by trade liberalization.

Our study provides insights into the evolution of productivity across spatial units in Korea with emphasis on the roles of trade costs reduction and improved infrastructure. The raw productivity-improvement effect of infrastructure is stronger than that of additional trade exposure, in particular, for the high-productivity spatial units. The medium-productivity spatial unit most strongly responds to trade costs reduction in comparison with other TFP percentile groups. Among the extended regions, the TFP of the most urbanized area, ER1 appears to be almost twice as elastic to infrastructure improvement as do those of other extended regions. Si/Guns in the remotest region, ER3, enjoy larger productivity enhancements due to declines of trade costs relative to other extended regions.

An important policy implication of this study is that a country pursuing foreign market opportunities to boost economic growth and to raise incomes, like Korea, should also consider the consequent spatial realignment of resources. Also, productivity enhancements along with transfers to alleviate adjustments to trade-cost changes cannot be space blind, but should sharpen the focus on the economic development of less-developed local regions.

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