Spatial Economic Analysis of Agro-food Industry in China

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ABSTRACT

The agro-food industry is an important sector for the Chinese economy. It is an extension of the primary sector and an efficient way to increase value added for agricultural output. Given its large production volume, the Chinese agro-food sector is the largest in the world as well. During the past three decades, it has experienced high growth. With continuing urbanization and income growth, demand for processed food will continue to increase. Therefore, new firms are being established by domestic, as well as foreign, investments.

The location problem is an issue of great concern in the economic literature. This dissertation describes the economic geography of the agro-food industry in China using geographic information system (GIS) tools. To do so, geographic coordinates are constructed using geo-coding techniques based on firm information from two national economic censuses in 2004 and 2008.

Firms are mapped based on the geo-coded data. The distributional features for some industries and the driving forces behind their locations are described and discussed. Some industries; for example, *Sugar Refinery*, *Aquatic Products Processing*, *Fish Products, Preserved and Dry Aquatic Food* and *Fish Oil Extraction and related Products*, are mainly determined by the location of raw materials, while other industries like *Aquatic Feed Manufacturing* and the *Yellow Wine* industry are located close to their consumers.

Also, I introduced the temporal dynamic for the distribution of the agro-food industry. During the past three decades, the output share between provinces has experienced changes. Statistics show that the center of agro-food production has shifted toward northern China. This is mainly attributed to the change

in comparative advantage between regions. In the 1990s, the southeast area, especially the Yangtze River Delta region, was a pioneer of China's economic reform and open policy. The regions within this area are abundant in capital and technology in terms of industrial production. Therefore, during the 1990s, the agro-food industry, along with other industrial sectors, was first developed in these regions. With economic development and access to international markets, the Yangtze River Delta area had a comparative advantage in producing export-oriented goods. In contrast, by taking advantage of abundant land resources and agricultural output, the provinces in the North China Plain had a comparative advantage in the agro-food industry. Thus, the center for the agro-food industry has shifted from southern to northern areas.

Agglomeration is considered to be an important feature in the location of the agro-food industry in China. To measure the extent of agglomeration, I estimate an agglomeration index for 2004 and 2008. To alleviate the modifiable unit area problem (MUAP), the third generation index, as proposed by Duranton and Overman (2005) and Duranton and Overman (2008) (DO index, henceforth), is employed. It is based on continuous space. Therefore, it is not sensitive to the division of geographic units, thus satisfying most of the properties that an ideal index should have (Combes, Mayer, and Thisse, 2008). Using geographic data, the real kernel density is estimated for a range of distances. Then, a counterfactual is constructed by random sampling from the location pool. Such re-sampling is repeated for a thousand times. After each re-sampling, the kernel density is estimated, as noted above. A global confidence interval is derived from the lower and upper 5% of these densities.

The results suggest that: (1) half of the four-digit industries in the agro-food sector are agglomerated; (2) the extent of agglomeration for the agro-

food industry in China is relatively higher than that in other countries; (3) the agglomeration pattern is persistent between 2004 and 2008; (4) the most agglomerated industries include *Yellow wine*, *Aquatic frozen*, *Sugar refinery* and *Food additive* industry; and (5) food processing (C13) industry, which relies on primary raw material more intensively than the other agro-food sectors, is shown to be more agglomerated than the food manufacturing and beverage industries. This could be attributed to the uneven distribution of agricultural products nation wide. Considering the area of China and the properties of some agricultural products, some raw materials are not easily mobile across regions. Therefore, the agglomeration of raw material inputs would induce agglomeration of the agro-food industry.

Industrial linkages (*forward* and *backward* linkages) playa certain role in the location choice of firms. Such phenomena are termed as "co-agglomeration". I discuss the potential relationship between industrial linkages and industry co-agglomeration via firm-distribution maps and input-output tables. Evidence suggests that strong input-output linkages may induce the co-agglomeration of industries. To put it simply, industries with input-output relationships are more likely to locate close to one another.

Next, I explore the locational determinants for newly established agro-food firms. In particular, I focus on the relative importance of resource endowments, industrial linkages, and agglomeration effects on the location choice of entry. Since the agro-food industry in China started to boom at the beginning of the 2000s, 2004 was chosen because the *First National Economic Census* conducted in that year provided the entry data.

In this investigation, each prefecture is treated as a unit of observation. In total, there are 286 regions, including 282 prefecture cities and four municipal-

ity cities. The number of firms established in 2004 in each prefecture served as the dependent variable. The firms' entry data are collected from the *First National Economic Census of China* conducted in 2004. The identification of establishing and existing status is based on the establishment year recorded in the dataset. This dataset has an advantage in that it includes all the registered firms, regardless of ownership and size. Therefore, its coverage is much wider than other available firm-level datasets. This is a significant advantage of current research. Resource endowment is measured by the area of agricultural land for each prefecture. Since the food processing industry mainly processes raw materials and produces semi-processed products, which are used as inputs for the food manufacturing (C14) and beverage making (C15) industries, food processing is regarded as an upstream industry, while the food manufacturing and beverage making industries are regarded as the downstream industries. For the downstream industries, industrial linkages are measured by the number of upstream industry (food processing, C13). Industrial linkages and agglomeration effect data are collected from the *First National Economic Census of China*. Agglomeration effect variable is constructed using the number of incumbents (existing firms) belonging to the same industry in 2004. Other prefecture attributes, are extracted from the *China City Statistical Yearbook 2004* and the *China Statistical Yearbook for the Regional Economy 2004*.

Since regional data have a spatial dimension, there are concerns about spatial correlation. Mapping the density of entry also reveals that entry behavior has a tendency toward clustering. Therefore, it is necessary to perform spatial correlation tests for the adoption of appropriate models. Both Moran's I test and Geary's C test indicate that spatial correlation exists between observations for the key variables of interest. In order to account for spatial correlation, I

employ spatial econometrics models. Although various specifications with different combinations of spatial effects exist in theoretical econometric model, Spatial Durbin Error Model (SDEM), Spatial Durbin Model (SDM) and the Spatial Lag of x (SLX) Model are considered to be practically feasible. The next question concerns the most appropriate specification among the four. Bayesian model selection results suggest that that SDEM is the most likely specification for all three industries.

Aside from the measures for the agglomeration economy and industrial (backward) linkages, other relevant variables are also considered in the estimations. *Agri land* is used to measure resource endowment for agricultural raw materials. Market size is measured by *GDP per capita*. The variable *Road*, which is the distance of paved roads, served as a proxy for infrastructure. *Policy* means the number of spatial economic zones in each prefecture. This is used to represent the effect of fiscal policy which may attract new investments.

To estimate a spatial model, a spatial weight matrix should be prepared. An adjacency based spatial weight matrix is constructed in *Geoda* and *R*. Three sets of models are estimated for SDEM. Because of the concern of high correlation between *Wage* and *GDP per capita*, these variables are included separately in the two models.

The estimation results from SDEM show that the coefficient of *NO.C13* is positive and significant for the food processing industry (C13). Such parameters for the C14 and C15 industries are both positive and significant, as well. This confirms the importance of agglomeration in the location choices for all three industries. The coefficient of the variable measuring backward linkages (*NO.C13*) is positive and significant for the C14 and C15 industries, indicating that industrial linkages play a significant role in the locational choice of

entrants in the agro-food sector. As expected, other factors, such as wage, negatively impacts the location choice of agro-food firms. Market access, measured by population and GDP per capita, are important for the food manufacturing and beverage making industries, both of which are demand-oriented. Spatial spillovers (neighboring effects) are also detected to some extent. To ensure the robustness of the above findings, I estimate spatial econometrics models with other combinations of spatial effects. Estimation results of SDM and SLX model support the main conclusions derived from SDEM.

In considering the existence of individual effects, I use panel data and construct an input-output table based measure for industrial linkage. Panel data are derived from the 2004 and 2008 national economic censuses. The input and output relationships are calculated by weighting the input and output coefficients in 2007 and the volume of production for each industry. To capture the different effects of such linkages for the food and nonfood sectors, input and output relationships are decomposed into food and nonfood linkages.

For the short-panel set ($T = 2$ in this case), the fixed effects estimator leads to inconsistencies for all variables in the case of the nonlinear panel model (Cameron and Trivedi, 2009). Moreover, some prefecture attributes between years are constant, which cannot be estimated by the fixed effects model. Therefore, I adopt the Poisson count model with pooling and random effects and control neighborhood effects. In the estimation, both *GDP* and *Population* are used to measure market size. For robust purposes, *Agri land*, which represents the area of agricultural land, serves as another measure of resource endowment, in addition to *Primary GDP*, which indicates the output of the primary sectors. Dummies indicating whether a prefecture is a capital city in a province (*Capital city*) and coastal city (*Coastal city*) are controlled for in the estimations.

Correlations between some attributes are high, such as *Wage* and *GDP* (0.647 and 0.684 in 2004 and 2008, respectively), and *Primary GDP* and *Population* (0.855 and 0.827 in 2004 and 2008, respectively). Therefore, in Model 3, *Population* replaces *GDP* as the indicator of market size. For the same purpose, *Primary GDP* and *Population* are not included in a single specification.

Unexpectedly, the results of the pooling and random effects model are not consistent in various aspects. Considering the existence of individual effects, the random effects model is preferred over the pooling model. The main conclusions are drawn from the random effects model.

The effect of agglomeration on firm entry has been confirmed for all agro-food industries in China, suggesting the existence of externalities generated by agglomeration. The importance of input and output linkages could not be established. However, resource endowment is found to be a significant predictor for entry, which suggests that the motivation for accessing intermediate goods or their downstream firms is not as strong as accessing raw materials. Such findings could possibly be justified by the input structure of the agro-food industry. The *2007 Input and Output Table of China* shows that the majority of inputs for the agro-food industry comes from the primary sector. Market size has also been confirmed to be important in some extent. Coastal and capital cities are found to be the desired locations for investors in the food industry. The effect of infrastructure is found to be inconsistent with theoretical predictions. This is perhaps caused by the improper measurement of infrastructure. Coastal and capital cities seem to be more attractive for investments.

This dissertation improves our understanding of the economic geography of the Chinese agro-food industry. Findings about locational determinants also have important implications for the the policy designs toward enhancing eco-

nomic development, as well as for the locational choices of newly established firms. China is a country with severe rural-urban gap and regional disparities. Narrowing these gaps has always been the central effort of all levels of governments. Food processing firms are often regarded as potential sources of growth for rural areas.

Although this dissertation is a step forward in our understanding of economic geography and the locational determinants of the agro-food industry in China, work remains to be done and other issues need to be further explored. In the economic geography literature, the source of agglomeration externalities is another important concern (Ellison, Glaeser, and Kerr, 2010). Further research is required to examine the driving forces of agglomeration.

Empirical evidence shows that the locational behavior of foreign and domestic firms could differ (Yang, Chiu, and Tsou, 2016). It is also commonly acknowledged that the locational motives for private and state-owned firms are also distinct. It would be insightful to explore the relative importance of locational determinants for various kinds of firms.

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