

Agglomeration Economy and Input–output Linkage: Evidence from the Entry of the Agro-food Industry in China

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The agro-food industry in China has experienced continuous growth during the last two decades. With booming domestic demand and increasing international trade, numerous firms are expected to be established in the near future. By spatial econometrics model, this research investigates the effect of agglomeration economy and input–output linkage on the setting up of agro-food firms in China. Results suggest that agglomeration economy and input–output linkage strongly predict the entry of firms into the agro-food market. Our finding provides potential insights for the development of rural areas as well as for the location choice of food firms.

Key words: agglomeration economy, input–output linkage, Chinese food firms

1. Introduction

With its large population, China is the largest producer and consumer of food in the world. The growth of the agro-food industry in China has been impressive, with the annual growth rate in double digits during the past 20 years.

With urbanization and income growth, the processed food market in China is expected to boom drastically. China also plays an important role in international food market, especially in East Asia (Wu and Shuto, 2016).

Also, a large amount of FDI is flowing into the Chinese food market. Food processing companies from Europe and North America, such as Danone, Coca-Cola, Kraft, MasterFoods, Nestlé, PepsiCo, and Tyson, have invested in joint ventures in China and will expand their businesses in the near future (Hawkes, 2008).

In general, agro-food industry in China is quite underdeveloped compared with more developed economies in the world. With booming domestic demand and increasing international trade, a large number of agro-food firms are expected to start up in the near future in China. Then, the question arises as to what factors attract new agro-food firms.

Agglomeration theory suggests that there are great benefits for firms locating together; therefore, new firms are more likely to start up in places where there are already a large number of incumbents from the same industry. From

the perspective of evolutionary economy geography, spin-offs, which are partly separated from existing firms, are the main drive of entrepreneurship. As has been confirmed

by Wu *et al.* (2016), the extent of agglomeration for food industry is high in China. Especially, the extent of agglomeration is higher than that in other countries. Therefore, it would be interesting to know whether agglomeration effects play an important role in the location choice for food firms.

Aside from agglomeration economy, input–output linkage is also important for newly established firms. (Glaeser and Kerr, 2009) found that city demographics, or a culture of entrepreneurship, have very limited roles in explaining the patterns of firm entry across cities in US. Rather, new entrants are particularly drawn to areas that have many small suppliers. The agro-food industry consumes large quantities of the output from such upstreaming industries.

Food sector is a pillow industry for rural areas in China. Attracting food firms is believed to be an effective way to narrow the gap between rural and urban areas. Understanding the location detriments of food industry, especially the effect of agglomeration economy and input–output linkage would contribute to making use of their comparative advantage for rural areas. Meanwhile, for food firms, agglomeration economy and input–output linkage are effective ways of cost saving. Thus this research would contribute to the location choice of food firms in China.

In particular, we consider the spatial effect in this research by employing the *Spatial Durbin Error Model*

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(SDEM) as well as *Spatial Durbin Model* (SDM) (J. LeSage and Pace, 2009), which allows for spillovers into neighboring observations.

2. Literature Review and Data

1) Literature review

Numerous studies have investigated the location determinants of food-related firms. Henderson and McNamara (1997) found that communities with an established manufacturing base and agglomeration economies are more likely to experience growth. Results from (Henderson and McNamara, 2000) confirm the importance of input–output linkage in the choice of location of food manufactures in the U.S. (Schmit and Hall, 2013) found that both agglomeration economy and market access are important for the growth of the food manufacturing industry in the U.S.

Other factors such as urbanization economies, product markets, available labor force, wage levels, and transportation infrastructure also attract food manufacturing investment (Davis and Schluter, 2005; Lambert and McNamara, 2009; Lambert *et al.*, 2006a; Stewart and Lambert, 2011).

Thus, our hypothesis is that firm entry is more likely to occur in prefectures where a large number of incumbent firms belonging to the same industry exist (agglomeration economy). Also, the existence of upstreaming firms has a positive effect on entry (input–output linkage).

2) Data

There are mainly two data sources in this research. Number of entry and number of incumbents for each industry are collected from The 1st National Economic Census of China in 2004. It has its advantage compared with survey data commonly used in the literature since in this survey, all enterprises regardless of size are included. The second data source is the China City Statistical Yearbook 2004 from which spatial attributes data are constructed.

In the Chinese Industrial Classification system, there are three two-digit industries belonging to the agro-food industry: C13, C14, and C15, which correspond to the food processing, food manufacturing, and beverage making industries, respectively. Food processing (C13) firms mainly process raw agricultural products. The outputs of the food processing industry are partly used as input in food manufacturing and beverage making firms. Therefore,

input–output linkages exist between the food processing industry and the other two agro-food industries.

In 2004, there were 7017 newly established firms in the food processing industry across the 286 regions, 2845 newly established food manufacturing firms, and 2123 newly established beverage making firms.

3. Empirical Approach

1) Empirical model

Various specifications for spatial econometrics have been developed during the past few decades. Despite the abundant availability in the toolbox, when investigating spillover effects, there are only two model specifications worth considering. (LeSage, 2014b). If the spillover is local, which suggests that the spillover involve only neighbors, Spatial Durbin Error Model (SDEM) is appropriate. In contrast, when the spillover is global, which involve higher-order neighbors, Spatial Durbin Model is usually employed. If there is theoretical background specifically indicating local or global spillover effect, then there is no need to perform specification tests. Since there is no specific theoretical underpinning suggesting the spillover in this research is local or global. We consider SDEM model as our benchmark and conduct SDM as robustness check.

Spatial Durbin Error Model (SDEM) (LeSage and Pace, 2009) allows for local spillovers to neighboring observations through spatial lag terms for the explanatory variables to account for the spatial effect. A similar approach is adopted in the research of LeSage and Ha (2012) to assess the impact of migration on social capital. It takes the form as follows.

$$y = X\beta_1 + WX\beta_2 + u \quad (1)$$

$$u = \lambda Wu + \varepsilon \quad (2)$$

$$\varepsilon \sim N(0, \sigma_\varepsilon^2 I_N) \quad (3)$$

where y is the number of newly established firms in 2004 in one prefecture and X is the vector of local attributes determining the firms' entry.

The spatial weight matrix W is of dimension $n \times n$, where n is the number of observations. Non-zero elements in row i and column j indicate that region i is a neighbor of region j . The main diagonal elements are zero, and rows are normalized so that elements of each row sum to unity. u is the error term. λ measures the strength of dependence between units.

Parameters λ , β_1 and β_2 are estimated by a maximum likelihood estimation (Bivand and Piras, 2015). In SDEM

model, β_1 is the direct effect, while β_2 captures the (cumulative) indirect effect (Vega and Elhorst, 2015). By cumulative it means that the coefficient β_2 denotes the sum of spillovers falling on all neighbors (LeSage, 2014).

2) Location determinants

(1) Agglomeration effects and Input–output linkage

Firms locating close to each other benefit from agglomeration from channels of labor market pooling, input sharing and knowledge spillover. Agglomeration factors are assumed to be positively associated with the birth of new firms. In the case of food industry, agglomeration economy has been extensively recorded in the literature (Goetz, 1997; Henderson and McNamara, 1997; Henderson and McNamara, 2000; Cohen and Paul, 2005; Lambert and McNamara, 2009). In this research, number of existing firms belonging to the same industry is used to measure the extent of agglomeration economy. As an example, for food processing industry (C13), number of existing firms in C13 industry (NO_EX_13) captures the effect of agglomeration economy.

Supplier access is regarded as an important factor predicting the entry of new firms, especially in the perspective of New Economic Geography (Amiti and Smarzynska Javorcik, 2008). Although input market condition is usually included in the analysis of location choice for food firms (Lambert *et al.*, 2006b; Lambert and McNamara, 2009), industrial linkage between agro-food sectors has rarely considered in the literature. Based on IO table and price information, Amiti and Smarzynska Javorcik (2008) construct measure for supplier access and found that access to market and suppliers are the most important factors affecting foreign firm entry in China. For agro-food firms, motivation to be close to supplier would be strong since intensive transport of bulky input and perishable nature of food ingredients. As had been mentioned before, food processing industry (C13) is the upstreaming of food manufacturing (C14) and beverage making industry (C15). Based on these facts, number of existing firms in C13 industry (NO_EX_C13) is used to measure input–output linkage for C14 and C15 industry.

(2) Product market (POP and GDP_Per)

For food firms, product markets are the source of final demand, therefore approximation to product market is favored as an incentive to minimize distribution costs, as well as save time. Goetz (1997) found that access to markets had a positive effect on food manufacturing

location choice in US. Similar facts had been confirmed at county level in US (Henderson and McNamara, 1997; 2000).

Following Lambert and McNamara (2009), population is served as the measure for market size. It is expected that POP will be positively associated with the entry, especially for food manufacturing industry and beverage making industry, whose outputs are consumed as final products. Meanwhile, purchasing power is another aspect that influence demand, so GDP per capital (GDP_Per) is also included in the estimation as a measure of market size

(3) Labor cost (WAGE)

Locations with lower labor costs have lower operating costs, increasing the attractiveness of a prefecture for food firms. It is expected that labor costs will be negatively associated with agro-food firms' entry. Average wage level (WAGE) for in 2004 in each prefecture is used to measure labor cost.

(4) Transport Infrastructure (ROAD)

Transport infrastructure is the basis to support business activities. Firms locating in areas with well-developed transport network have better access to product and material market, as well as lower transportation costs. Thereby increasing their competitiveness. Thus we use the length of road (ROAD) in one prefecture to measure the influence of transport network on the birth of new firms.

(5) Agriculture output (AGLD)

Agro-food sector also procures from agriculture sector as inputs. As abundant agricultural products indicates access to raw material for agro-food sector, low price as well as saving of transport cost and time, agriculture output is hypothesized to attract agro-food firms (Lambert and McNamara, 2009). We use land size for agriculture production (AGLD) to proxy the output.

(6) Area of prefecture (AREA)

In consideration of fact that the size of prefecture may influence the birth of new firms (it is natural to expect more entry in larger prefectures), area of prefecture is included in the regression as a control.

(7) Policy determinants (EcoZone)

Investment decisions of firms are easily influenced by local policy such as tax holiday. Government of China has established many economic zones to attract investments all over the country. Firms locating in these economic zones could enjoy tax reduction as well as other subsidies. In this analysis number of economic zones in each prefecture is

Table 1. Summary statistics of variables

Label	Mean	S.D.	Min	Max	Units
NEW_C13	25	31	0	217	firm
NEW_C14	10	13	0	84	firm
NEW_C15	7	8	0	47	firm
POP	412	289	17	3144	person
AREA	16410	21875	1113	253400	km ²
GDP_Per	13770	11788	2126	72000	yuan
WAGE	13710	4282	6207	31930	yuan
AGLD	329	297	3	2106	1000 ha
ROAD	5482	3983	277	34000	km
EcoZone	0.17	0.46	0	4	zone
NO_EX_13	218	239	0	1455	firm
NO_EX_14	95	124	0	933	firm
NO_EX_15	81	93	0	798	firm

Note: Detailed explanations for variable label are in section 3.

used to proxy the policy effect.

Table 1 is the summary statistics of variables, NEW_C13 (NEW_C14, NEW_C15), which is the dependent variable in the estimation, means the number of newly established firms in food processing (food manufacturing, beverage making) industry.

4. Results and Discussion

1) Benchmark results: SDEM estimation

Table 2 presents the estimation results of Spatial Durbin Error Model for the three industries. Both Wald test and LR test are significant for three models, justifying the existence of spatial dependence. For the food processing industry (C13), the variable indicating labor cost (WAGE) has a slightly significant negative effect on the entry of new firms, implying that food processing firms are more likely to be located in prefectures where wages are low. The parameter measuring the agglomeration effect (NO_EX_13) is positively significant at the 1% level, suggesting that food processing firms are attracted to prefectures where there are large numbers of incumbents from the same industry.

Similar to food processing industry (C13), labor cost (WAGE) also negatively affects the entry of firms in food making industry (C14). However in some aspects the results of food manufacturing industry (C14) exhibit features different than the food processing industry. Market access, measured by population (POP) and purchasing power (GDP_Per), positively predicts entry. Notably, this factor

was not significant for the food processing industry. The reason behind this is easy to interpret: the output of the food processing industry is mainly for industrial use, while the products of food manufacturing are mostly consumed by consumers. Agglomeration economy (NO_EX_14) is confirmed as a factor in food manufacturing industry (C14).

It indicated that the presence of incumbent firms has a significant effect on the entry of new firms for food manufa-

Table 2. Estimation results of SDEM

	C13	C14	C15
POP	0.00010 (0.00756)	0.00723** (0.00283)	0.00237 (0.00215)
AREA	-0.00003 (0.00005)	-0.000003 (0.00002)	-0.00001 (0.00001)
WAGE	-0.00070* (0.00042)	-0.00030* (0.00016)	-0.00008 (0.00012)
AGLD	0.00542 (0.00587)	0.00194 (0.00221)	0.00082 (0.00168)
GDP_Per	0.00001 (0.00015)	0.00012** (0.00005)	-0.00001 (0.00004)
EcoZone	-0.33209 (2.79216)	-0.89259 (1.01019)	-0.30420 (0.76251)
ROAD	0.00039 (0.00032)	0.00010 (0.00012)	0.00021** (0.00009)
NO_EX_13	0.10347*** (0.00662)	0.00477* (0.00250)	0.00487** (0.00189)
NO_EX_14	-0.00403 (0.01389)	0.06279*** (0.00518)	-0.00287 (0.00393)
NO_EX_15	0.00184 (0.01496)	0.01004* (0.00557)	0.04598*** (0.00422)
Lag			
POP	-0.01218 (0.01257)	-0.00160 (0.00434)	-0.00347 (0.00327)
AREA	-0.00003 (0.00011)	0.00003 (0.00004)	-0.00002 (0.00003)
WAGE	-0.00025 (0.00076)	0.00012 (0.00026)	0.00048** (0.00020)
AGLD	0.00136 (0.00871)	-0.00243 (0.00300)	0.00052 (0.00226)
GDP_Per	0.00023 (0.00023)	0.00002 (0.00008)	-0.00009 (0.00006)
EcoZone	-1.68390 (5.49890)	-1.61873 (1.98703)	0.31578 (1.49957)
ROAD	0.00037 (0.00066)	-0.00011 (0.00023)	-0.00014 (0.00017)
NO_EX_13	0.01276 (0.01172)	0.00787* (0.00405)	0.00589* (0.00304)
NO_EX_14	-0.00271 (0.02482)	0.00382 (0.00860)	-0.00493 (0.00646)
NO_EX_15	0.01526 (0.02874)	-0.00437 (0.00983)	0.01823** (0.00738)
Constant	8.17320 (10.34251)	-1.10254 (3.35353)	-3.27455 (2.50036)
Observations	286	286	286
Log Likelihood	-1,181	-896	-816
Akaike Inf. Crit.	2,408	1,838	1,678
Wald Test (df=1)	21.76***	6.28**	4.40**
LR Test (df=1)	22.10***	6.08**	4.28**

Note: 1) * p<0.1; ** p<0.05; *** p<0.01

2) Numbers in parentheses are standard errors.

cturing industry. Variable representing input–output linkage (NO_EX_13) is significant for food manufacturing industry, suggesting that the presence of upstream industry (food processing) would promote the entry of firms in downstream industry (food manufacturing). Moreover, significance of NO_EX_13 in lag term proves spillover effects of input–output linkage. It means the presence of upstream industry in one prefecture even encourages the entry of downstream firms in its neighbor prefectures.

Table 3. SDM as Robustness check

	C13	C14	C15
POP	0.00046 (0.00390)	0.00732** (0.00286)	0.00237 (0.00215)
AREA	-0.00003 (0.00005)	-0.000004 (0.00002)	-0.00001 (0.00001)
WAGE	-0.00064 (0.00045)	-0.00030* (0.00015)	-0.00011 (0.00012)
AGLD	0.00555 (0.00524)	0.00205 (0.00220)	0.00092 (0.00163)
GDP_Per	-0.00004 (0.00018)	0.00011*** (0.00004)	-0.00001 (0.00004)
EcoZone	-0.24076 (2.61751)	-0.84746 (0.97281)	-0.30899 (0.75776)
ROAD	0.00040 (0.00039)	0.00011 (0.00012)	0.00022** (0.00009)
NO_EX_13	0.10175*** (0.00684)	0.00411 (0.00250)	0.00451** (0.00193)
NO_EX_14	-0.00410 (0.02055)	0.06292*** (0.00522)	-0.00248 (0.00398)
NO_EX_15	0.00221 (0.02150)	0.01033* (0.00557)	0.04521*** (0.00429)
Lag			
POP	-0.00992 (0.01408)	-0.00310 (0.00402)	-0.00362 (0.00304)
AREA	-0.00001 (0.00030)	0.00003 (0.00004)	-0.00002 (0.00003)
WAGE	-0.00008 (0.00107)	0.00015 (0.00114)	0.00046** (0.00019)
AGLD	-0.00219 (0.01320)	-0.00256 (0.00281)	0.00028 (0.00184)
GDP_Per	0.00028 (0.00030)	0.000003 (0.00024)	-0.00008 (0.00006)
EcoZone	-2.79163 (6.88125)	-1.46114 (1.91084)	0.53842 (1.45873)
ROAD	0.00012 (0.00111)	-0.00012 (0.00021)	-0.00017 (0.00016)
NO_EX_13	-0.02601* (0.01332)	0.00675* (0.00399)	0.00452 (0.00305)
NO_EX_14	0.00298 (0.02751)	-0.00947 (0.00942)	-0.00381 (0.00620)
NO_EX_15	0.01036 (0.02777)	-0.00539 (0.00816)	0.00691 (0.00827)
Constant	6.13609 (10.73305)	-0.88451 (2.29841)	-2.85897 (2.17790)
Observations	286	286	286
Log Likelihood	-1,180	-895	-815
Akaike Inf. Crit.	2,406	1,837	1,676
Wald Test (df=1)	26.86***	7.40***	6.36**
LR Test (df=1)	23.80***	7.01***	6.06**

Note: 1) * p<0.1; ** p<0.05; *** p<0.01

2) Numbers in parentheses are standard errors.

Estimates for beverage making (C15) industry highlights the role of transport infrastructure (ROAD). Significance of variables NO_EX_13, NO_EX_15 and their lag terms imply that agglomeration economy and input–output linkage matters as well for this industry.

2) Robustness check: SDM estimation

In consideration that global spillover effect might exist, we estimate Spatial Durbin Model as the robustness check. In such case, a change of X at any region will be transmitted to all other regions even if two regions, according to W , are not adjacent (Vega and Elhorst, 2015). SDM takes the form as follows.

$$y = \rho W y + X \beta_1 + W X \beta_2 + \varepsilon \quad (4)$$

$$\varepsilon \sim N(0, \sigma_\varepsilon^2 I_N) \quad (5)$$

SDM differs with SDEM in that it has a lag term for dependent variable in the right hand side and the error term structure is not spatially correlated.

Table 3 shows the estimation results of SDM. In general, variables suggesting the importance of agglomeration economy and input–output linkage are still significant, although some variables (NO_EX_13 for C14 industry, lag term of NO_EX_13 and NO_EX_15 for C15 industry) lose their significance. Other variables, reflecting market size (POP and GDP_Per), labor cost (WAGE), and transport infrastructure (ROAD) are also very similar to those in SDEM setting.

In summary, main results suggesting the importance of agglomeration effect and input–output linkage are robust under SDM specification.

5. Conclusion

Using the Spatial Durbin Error Model, this research investigates the effect of an agglomeration economy and input–output linkages on the setting up of new firms in the Chinese agro-food industry. Results suggest that an agglomeration economy and input–output linkages strongly predict the entry of new firms into an area. The existence of firms from the same industry also has a positive effect on the starting up of firms. As an upstreaming industry, food processing (C13) firms attract the entry of both food manufacturing (C14) and beverage making (C15) industries. Main results are robust under different model specifications.

China is a country with severe rural-urban gap and regional disparity. Narrowing these gaps has always been the central effort for all levels of governments. Food processing firms are often regarded as potential growing

sources for rural areas (Lambert *et al.*, 2006b). Findings from current investigation suggests new firms are more likely to locate in prefectures where large number of similar firms and suppliers with industrial linkage have already exist. Policies encouraging the clustering of agro-food industry as well as fostering industrial linkage would be an effect way to attract agro-food firms to locate in rural and less developed regions, thus enforcing rural development and regional balance. Jobs brought by the establishment of new firms are also an important source of income for farmer since most employee of agro-food firms comes from part-time farmer.

Echoed with the finding of Cohen and Paul (2009), which revealed significant spillover effect in terms of cost for agro-food firms from proximity to other food manufacturing centers, our findings suggest motivation of agglomeration economy and input-output linkage do exist such that new firms are more likely to born in place where there are already large number of similar and upstream firms, although the detailed mechanism hasn't been analyzed and more like a 'black-box', which require further investigation. Give the potential of food market in China, large number of agro-food firms are expected to be established in the coming future. Our findings provide helpful insight for the location choice of new firms in agro-food sector.

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