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# Spatially correlated exit strategies in the baking industry

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This article uses a unique data set to analyse economic factors that explain firm exit and the interrelation across firms in space when exiting. Results show the effectiveness of modelling spatial correlation in a logit exit model. Indeed, in our application, reliable statistical results could only be drawn from our data when including spatial correlation in the model.

## I. Introduction

The US baking industry is typical of many agricultural processing industries of perishable products. The industry is highly competitive with a nominal growth rate that varies across products and plants prefer to locate in population areas with greater density. Perishablility of the product implies that local markets and competitive conditions affect firms' profits and their survival. The presence of transfer costs in bread distribution and other bakery products, moreover, implies that firms in this industry are widely dispersed across USA, and yet highly spatially interdependent with a diverse ownership capital-base.

The bakery industry features intense competition in local markets. Firm success in this industry may be limited to the ability to dominate a local market and to economic factors that influence firm decisions within a geographical area. Hence, in explaining firm exiting decisions in the bakery industry, it is expected that firms' payoffs from exiting the industry are correlated with neighbouring firm choices. In effect, modelling the firm decision to exit the industry involves a dichotomous choice variable and each firm decision of exiting the industry is likely to be correlated with other firms' choice of exiting. However, econometric modelling of spatial correlation in the probability of exit is scarce (Schary, 1991).

For cases with continuous dependent variables, the impact of inclusion of spatial correlation with firm-level data has been shown in various applications (Sarmiento, 2004; Florkowski and Sarmiento, 2005; Sarmiento, 2005), whereas empirical applications of spatial correlation with dichotomous choice variables are much less common. To estimate the logit model with spatial correlation, Dubin (1995) simulates spatially autocorrelated data using a two-step process, whereas Sarmiento and Wilson (2005) estimates the model by concentrating the likelihood function in terms of the spatial correlation coefficient.

In the bakery exit model, application of the concentrated likelihood logit function yields estimates of the spatial correlation coefficient in the dichotomous decisions to exit or not exit, and results illustrate that the inclusion of this effect substantially improves efficiency of the estimator. Indeed, this effect is very large. Without a spatial lagged dependent variable (spatial correlation in exiting), only one out of 10 variables is statistically significant, while seven out of 11 variables are significant when including spatial correlation. In effect, in the modelling of firm exiting decisions, inclusion of spatial correlation is shown essential to illicit factors that explain firm exit. Without including the spatial correlation the results are statistically ambiguous. With the bakery data, statistical analysis of spatial correlation permits contending hypotheses of firm exit to be evaluated in our application. The structure

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of the baking industry and the spatial component underscored in the article, moreover, provides a useful contrast to other empirical analyses that explain determinants of firm exit (e.g. Lieberman, 1990; Deily, 1991; Anderson *et al*., 1998).

## II. Economics of Exit

Understanding factors impacting exit and plant closure has been an important area of study in industrial economics (Agarwal and Gort, 1996). Generally, these analyses use firm, plant and industry characteristics to explain plant closure. Factors that contribute to explaining firm exit are plant size, firm market share, the number of plants the firm owns, firm diversification, the age of the plant and financial characteristics of the firm. Greenhut *et al*. (1987) discusses some of the theories on location and the market-area principles. Among these are the cost theories of location by Von Thune and Weber, the location-interdependence theory, the market area school promoted by Loch and the theory of maximum profit plant location.

Because of the perishable nature of the product, bakery plants in USA are distributed closely to the population distribution. The baking industry is a local industry instead of a geographically concentrated industry because the products are not shipped long distances. Large baking firms will often have a number of plants in different geographic regions. Because of the perishable nature of the bakery products and the short distance they can be shipped, bakery firms have a greater incentive to operate plants in different regions than to operate a large centralized plant.

Hotelling describes the importance of competitor's location (Greenhut *et al*., 1987), in which firms strive to locate near the center of a market. The maximum-profit theory, on the other hand, provides a theory of how plant location could be dispersed. Plant dispersion would occur if a few large plants, which the smaller plants could not compete with, are located near the center of the market. The smaller plants, therefore, decide to locate in remote areas where there is unmet demand.

Strategic behaviour has an impact on exit. Besanko *et al*. (1996) define exit as a firm ceasing production and either re-deploying or selling off its assets. A firm will exit a market if it can no longer remain profitable. Exit barriers may, however, have an influence on a firm's exit decision. Other factors, such as the size of the plant or firm and the product life cycle, affect exit decisions. A risk-neutral, profit-maximizing firm will exit if the value of its assets in their best alternative use exceeds the present value from remaining in the industry. Exit barriers exist when firms have significant fixed costs and can limit the firm's incentive to exit. Fixed costs are obligations that the firm must meet regardless of whether it remains in operation.

Prominent theories that have been used to analyse strategic decisions about exit are shakeout and stakeout (Lieberman, 1990). The shakeout theory states that small firms close first because of lack of scale economies. Larger firms are more likely to survive because they are more efficient. The stakeout theory suggests that, in the absence of cost differences, smaller firms would remain profitable over a longer period. As demand falls, large firms exit first or drastically reduce capacity. The fundamental question Lieberman asks is whether large firm size is a strategic liability in a declining industry and if so, is this liability substantial enough to outweigh the cost advantage of achieving economies of scale? Lieberman (1987, 1990) analysed the chemical product industries found that small plants are more likely to close, indicating the existence of a shakeout and tested the possibility of a stakeout. He found that, while small plants are more likely to be closed, when controlling for plant size, the probability of closure increases with the firm's capacity share. Both the shakeout and the stakeout theories are supported in Lieberman's study.

Other studies in processing industries have analysed the impact of capacity on exit. Schary (1991) analysed the exit of firms in the New England cotton textile industry between 1924 and 1940 and found that large plants are less likely to close. Deily (1991) studied the integrated steel industry and found that smaller plants were found to be more likely to close. Anderson *et al*. (1998) modelled the determinants of exit from the cattle-slaughter industry. Plant capacity was found to be one of the most significant determinants of exit. The presence of economies of scale was supported. Controlling for other factors, smaller plants were found to exit at higher rates than larger plants.

The age of the plant and learning curve may also affect the probability of closure. The longer a plant has been open, the further it moves down the learning curve. An older plant would be expected to operate at a lower cost and have a higher probability of surviving. On the other hand, when a plant becomes older, it may become less productive because of outdated technology. Anderson *et al*. (1998) hypothesized that productivity would have a negative influence on exit. They used the age of the plant as a proxy for productivity, assuming newer capital is

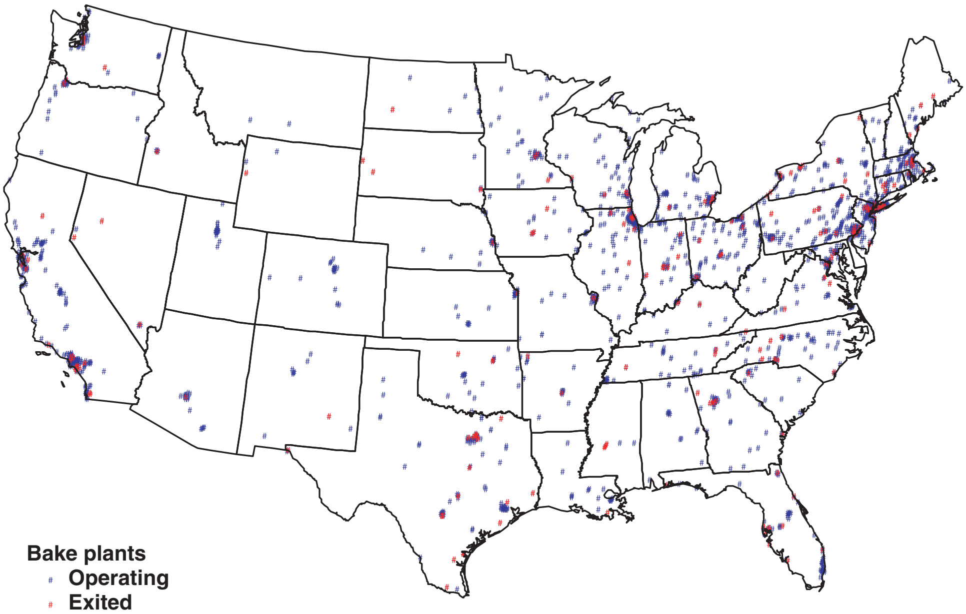


**Fig. 1. Concentration of Bake Plants**

more productive. Age was found to be a significant determinant of entry. It was found that, if a plant survives its first year, its probability of exit declines each successive year until age 20 and then increases. Older plants, therefore, are less likely to exit, until they reach a certain age.

Diversification may have an effect on exit. If economies of scope exist, a diversified plant may be less likely to close. Also, if a plant is producing two or more goods and demand for one of those goods fall, the plant may still be able to remain profitable. Diversification can reduce risk. Deily (1991) tested for the effect of diversification on plant-closing decisions in the steel industry from 1977 to 1987. Her results showed that diversification has no effect on closing decisions.

Anderson *et al*. (1998) tested the effect of within plant horizontal integration on exit. They stated that horizontal integration in the meatpacking industry can have two effects that would decrease the probability of exit. One is economies of scope. If economies of scope exist, the plant can produce both beef and pork at lower unit costs than it could if it produced each separately. The other effect is the premium that could be received for the convenience of providing buyers with two goods (beef and pork). Horizontal integration was measured with a dummy variable, indicating whether the plant produced more than one good. The results showed that horizontal integration has a significant and negative effect on the probability of exit. Anderson *et al*. concluded that economies of scope are supported in the meatpacking industry. Depending on the industry and whether economies of scope exist, the number of goods a plant produces may have an effect on the probability of exit. If it does have an effect, it most likely will be to decrease the likelihood of exit.

From agglomeration theory, firms in low-tech industries tend to concentrate (Moomaw, 1998; Feser, 2001) and this is indeed the case in the bakery industry (see Fig. 1). Within a smaller jurisdiction, however, industry concentration in the baking industry is limited by the characteristics of the product (e.g. fresh bread, bagels). In modelling firm exiting decisions it might be relevant to incorporate geographical information; local competition, and local economic shocks that affect all firms in a given area. Also, in the exit model, competition likely plays a role, in which firms that face larger competition are more likely to exit the industry and, of course, the decision to exit the baking industry is also likely to depend on the firm's own characteristics, e.g. the number of employees (bakeries are labour intensive).

## III. Data Sources

A data set on baking plants in USA was developed from the *Bakery Production and Marketing: Red Book* (Cahners Publishing Co.) and from the *Baking/Snack Directory & Buyer's Guide 1990 and 1998* (Sosland Publishing Company). The data set provides information on the firm and plant characteristics and

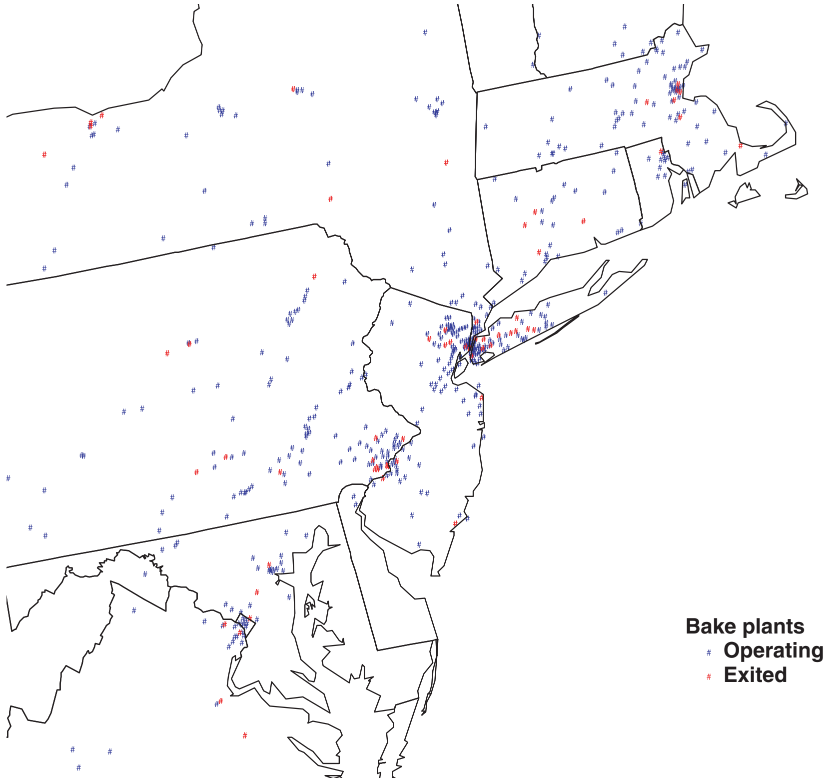


**Fig. 2. Concentration of Bake Plants on the East Coast**

those of the competitors. Geographical distance among locations was derived from the center of the city each firm is located using ArcGIS. Demographic county-level population data were extracted from the US Census Bureau. In the period of this study, there were 2121 plants and there were 286 that exited. Figure 1 shows the distribution of all bakery plants across space and the distribution of firms that exited, while Fig. 2 shows the distribution of firms in the Northeast, the area with the largest concentration of plants.

## IV. Firm Exit in the Presence of Spatial Correlation

### Model specification

To measure determinants of firm exit, a discrete choice model is specified in which a firm decision to exit the industry is the dependent variable that depends on firm characteristics, industry competition and location. Firm characteristics used as explanatory variables include number of employees $E_j$, the number of products $NP_j$, age of the firm $A_j$ and type of processed product (e.g. whether the bakery produces bread $DB_j$ and whether it produces begals $DBE_j$). Factors of demand and competition that explain firm exit are income of the county the firm is located $Y_j$, population density in the county $d_j$, size of competition $IC_j$ (i.e. average number of employees for bakeries within a 15 miles radius); and location of the firm (i.e. coordinates of the center of the firm city: latitude $LA_j$ and longitude $LO_j$).

In addition to these firm and competitor characteristics, other unobservable factors explain firm exit, and therefore only the probability of exit can be specified:

$$\text{Prob}(Y_j = 1) = F(I_j)$$

where

$$I_j = \alpha + \beta_1 E_j + \beta_2 NP_j + \beta_3 A_j + \beta_4 DB_j + \beta_5 DBE_j + \beta_6 Y_j + \beta_7 d_j + \beta_8 LA_j + \beta_9 LO_j + \beta 10 IC_j \qquad (1a)$$

and, if $F(\cdot)$ is a logistic distribution, then

$$\text{Prob}(Y_j = 1) = \frac{\exp(I_j)}{1 + \exp(I_j)} \qquad (1b)$$

The specification in Equation 1, however, ignores that a firm decision to exit the industry may be correlated with other firms' exit decisions. This correlation is likely to depend on location since firms in the bakery industry share the same local markets and are spatially interdependent. Hence, the probability of firm exit may also depend on whether neighbouring firms have exited the industry and, in this case, the maximum likelihood estimator of Equation 1 is inconsistent and inefficient. Following Dubin (1995), we note that the presence of spatial correlation across firms' choice set of exiting an industry is manifested with a spatial discrete lagged dependent variable:

$$SL_j = \sum_{k \neq j} D_{Fk} \exp\left(\frac{-\text{Dist}_{jk}}{\gamma}\right) \tag{2}$$

where $D_{Fk} = 1$ if firm $j$ exits industry and $D_{Fk} = 0$ else; and $\text{Dist}_{jk}$ is the distance between firms $j$ and $k$. The logistic regression with spatial correlation in the choice set incorporates Equation 2 into 1a is, therefore,

$$\begin{aligned} I_j &= \alpha + \beta_1 E_j \beta_2 NP_j + \beta_3 A_j + \beta_4 DB_j + \beta_5 DBE_j + \beta_6 Y_j \\ &\quad + \beta_7 d_j + \beta_8 LA_j + \beta_9 LO_j + \beta_{10} IC_j + \beta_{11} SL_j \\ &= \beta X_j(\gamma) \end{aligned} \tag{3}$$

where the probability of exiting the industry depends partly on whether competing firms have also exited the industry and the distance between competitors.

The impact of distance across firms that have exited the industry is:

$$\text{Prob}\frac{(\text{Exit}_j)}{D_{jk}} = \Lambda_j[1 - \Lambda_j]\left[D_{FK} \cdot \exp\left(\frac{-\text{Dist}_{jk}}{\gamma}\right)\right] \cdot \left(\frac{\beta_{11}}{\gamma}\right)$$

$$\text{for } \Lambda_j = \frac{\exp(I_j)}{1 + \exp(I_j)}$$

where if $\beta_{11} > 0$ and there are decreasing marginal transportation costs ($\gamma > 0$), then the probability of firm exiting the market increases when more affine competitors have also exit the industry. Interestingly, this qualitative result may be consistent with $\beta_{10} > 0$, i.e. firms facing larger competitors (more severe competition) are more likely to exit.

## *Estimation*

Distance in the spatial index in Equation 2 of the discrete choice model with spatial correlation enters nonlinearly because of uneven frequencies when defining lags in a spatial framework. Available software designed to estimate dichotomous choice models with spatial correlation data is not readily available. We thus developed a procedure to estimate the discrete choice of exit with an algorithm that converges easily. To do so, we concentrate the logistic likelihood function in terms of the nonlinear coefficient in the spatial correlation function (Sarmiento and Wilson, 2005). In particular, the estimator of Equation 1 with the index function in Equation 3 is obtained by solving the optimization:

$$\begin{aligned} &\underset{\gamma}{\text{Max}} \ln L(\gamma) \\ &\text{s.t.} \sum_i (y_i - \Lambda_i)\mathbf{X}_i(\gamma) = 0 \end{aligned} \tag{4}$$

where

$$\ln L(\gamma) = \sum_i y_i \ln\{\Lambda_j\} + \sum_i (1 - y_i) \ln\{\Lambda_j\}$$

and

$$y_i = 0 \text{ or } y_i = 1$$

Convergence of the algorithm estimated using GAUSS to solve the nonlinear logit model in Equation 1 under Equation 3 is illustrated in Table 1.

For the estimated scale parameter $\gamma$ (Table 1) the degree of firm interrelation increasingly intensifies as firms are more closely located to each other and value of $\gamma$ indicates the rate at which interrelation across firms decreases with distance. A positive value for $\gamma$ is consistent with the premise that transportation costs increase at a decreasing rate. Coefficient estimates that result from maximizing the likelihood function are reported in Table 2.

## *Evaluation of spatial correlation in the choice set of exit strategies*

This section evaluates the importance of location and distance to competitors in explaining the probability of firm exit. Specifically, the model is estimated with and without the spatial lagged dependent variable and three different specifications are estimated for purposes of evaluating firm exit decisions: Unrestricted nonlinear logit model in Equation 3; the restricted nonlinear logit model without the

**Table 1. Estimated log-likelihood function for different values of the scale parameter for distance**

| $\gamma$ | Log-likelihood |
|---|---|
| 100 | −835.768 |
| 10 | −797.449 |
| 4 | −791.81 |
| 3 | −790.344 |
| 2 | −788.211 |
| 1.5 | −787.102 |
| 1 | −787.993 |
| 1.4 | −786.979 |
| 1.3 | −786.945 |
| 1.2 | −787.048 |
| 1 | −787.993 |
| 0.5 | −803.585 |

**Table 2. Estimated logistic exit model**

| Variable/Coefficient | Unrestricted model | | Restricted model with no spatial correlation | | Restricted model with no Geog. coor. | |
|---|---|---|---|---|---|---|
| | Est | *t*-value | Est | *t*-value | Est | *t*-value |
| $\alpha$ | −0.286 | −0.37 | −0.729 | −0.98 | −0.268 | −0.34 |
| $E_j/\beta_1$ | −0.072 | −2.84* | −0.074 | −2.98* | −0.066 | −2.69* |
| $NP_j/\beta_2$ | −0.091 | −2.19* | −0.073 | −1.81 | −0.089 | −2.18* |
| $A_j/\beta_3$ | −0.125 | −0.82 | −0.135 | −0.92 | −0.122 | −0.82 |
| $DB_j/\beta_4$ | 0.341 | 2.30* | 0.256 | 1.75 | 0.309 | 2.11* |
| $DBE_j/\beta_5$ | −0.033 | −2.33* | −0.019 | −1.38 | −0.021 | −1.44 |
| $Y_j/\beta_6$ | −0.008 | −1.94 | −0.005 | −1.28 | −0.014 | −3.12* |
| $d_j/\beta_7$ | −0.001 | −1.15 | 0.0005 | 0.62 | −0.0011 | −1.22 |
| $LA_j/\beta_8$ | 0.255 | 1.16 | 0.189 | 0.88 | NA | NA |
| $LO_j/\beta_9$ | 0 | −6.22* | 0 | −0.66 | NA | NA |
| $IC_j/\beta_{10}$ | 0.171 | 2.013* | 0.188 | 1.758 | 0.161 | 1.871 |
| $SL_j/\beta_{11}$ | 0.69 | 9.83* | NA | NA | 0.32 | 6.94* |
| Value log-likelihood function | −786.95 | | −837.66 | | −815.34 | |

*Notes*: * indicates statistical significance at the 95% confidence level. NA indicates Not Applicable.

lagged dependent spatial variable in Equation 4 (i.e. $\beta_{11} = 0$); and the logit model without inclusion of geographical coordinates (i.e. $\beta_8 = \beta_9 = 0$).

Table 2 shows the estimated coefficients and log-likelihood functions of each model specification. The estimated logit models without the spatial dichotomous lagged dependent variable only resulted in the number of employees being statistically significant at a 5% significance level, while all other variables are not significant. Therefore, only one out of the 10 explanatory variables included is statistically significant.

In contrast, in the unrestricted model with a spatial lagged dependent variable (Table 2) seven out of 11 variables are statistically significant relative to the case of noninclusion of spatial correlation. Strikingly, from Table 2, inclusion of spatial correlation in modelling exit strategies increases fit substantially, improves precision of estimates and improves the economic inferences with statistical significance. Yet, different from the impact of spatial correlation in SE, point estimates of the marginal effects in Table 3 are relatively robust. The primary effect of the dichotomous spatial lagged dependent variables in the discrete choice formulation is on increasing efficiency (reduced SE) in estimation rather than in bias reduction.

Inspection of Table 2 further shows that the spatial correlation coefficient is the most statistically important coefficient, and therefore the most powerful effect in explaining firm exit. This implies that location is the most crucial factor explaining firm survival. Moreover, the fact that $\beta_{11} > 0$ indicates that a given state of nature results in similar firms exiting. This does not mean that competition reduces the likelihood of the firm to exit. Indeed, the positive value of $\beta_{11}$ is consistent with the result in Table 2 that firm exit increases with the competition intensity as measured by the size of the competition $IC_j$, i.e. $B_{10} > 0$.

### Qualitative analysis of estimates

The estimated parameters show that exiting an industry occurs in an economic environment dominated by the presence of spatial correlation across firms' payoffs from exiting the industry and the strength of this reaction is inversely related to distance. Qualitatively, firms are more likely to exit when competitors also exit ($\beta_{11} > 0$), while the probability of firm exit increases in the presence of larger competitors ($\beta_{10} > 0$). Both the presence of spatial correlation and proxies of heterogeneity (Sarmiento, 2004) based on geographical coordinate's location are statistically significant.

The models with spatial correlation (Table 2) show that plants with more employees (larger firms) and firms that produce multiple products are less likely to exit. Therefore, results support the shakeout theory that predicts that smaller firms are more likely to exit and product fragmentation reduces the probability of exit consistently with the notion that production of multi-products mitigates risk and/or increases profitability due to economies of scope. Interestingly, a bakery that produces bread is more vulnerable to exit the industry, while a bakery that produces bagels is more likely to not exit. This may be explained by the fact that production of bagels has more value added in production.

Table 2 also shows that the probability of exiting increases when competition is more intensive (i.e. competition is larger with operations that use

**Table 3. Marginal effects**

| Variable/Coefficient | Logistic exit model | Logistic exit model no spatial correlation | Logistic exit model no Geog. Coor. |
|---|---|---|---|
| $\alpha$ | −0.0282 | −0.076 | −0.0274 |
| $E_j/\beta_1$ | −0.0071 | −0.0077 | −0.0067 |
| $NP_j/\beta_2$ | −0.009 | −0.0077 | −0.0091 |
| $A_j/\beta_3$ | −0.0124 | −0.0141 | −0.0124 |
| $DB_j/\beta_4$ | 0.0337 | 0.0266 | 0.0315 |
| $DBE_j/\beta_5$ | −0.0033 | −0.002 | −0.0021 |
| $Y_j/\beta_6$ | −0.0008 | −0.0006 | −0.0014 |
| $d_j/\beta_7$ | −0.0001 | 0 | −0.0001 |
| $LA_j/\beta_8$ | 0.0252 | 0.0197 | NA |
| $LO_j/\beta_9$ | 0 | 0 | NA |
| $IC_j/\beta_{10}$ | 0.0169 | 0.0196 | 0.0164 |
| $SL_j/\beta_{11}$ | 0.0681 | NA | 0.0327 |



larger work force.) Moreover, estimates cannot reject the null hypothesis that age does not have an effect on the probability of exit, and yet numerically older firms are less likely to exit.

Estimates also show with strong statistical significance that firms in higher longitude (i.e. more western part of the USA) have less probability to exit the industry. This may be explained by a structure of the industry and economy with larger turnover in the east than in the more western locations. Demographical characteristics such as population density and income of the county where the firm is located are not significant. Lack of significance of these factors may be due to the demand for bakery product being income inelastic. In contrast, the primary factor that explains firm exit is spatial correlation, and thus the most significant factor that precludes firm exit is finding a location where neighbours are successful.

The application of the algorithm yielded estimates of the spatial correlation coefficient in the dichotomous decisions to exit or not exit and results illustrated that the inclusion of this effect substantially improves efficiency of the estimator. Indeed, this effect was very large. Without a spatial lagged dependent variable (spatial correlation in exiting), only one out of 10 variables is statistically significant, while seven out of 11 variables are significant when including spatial correlation. Thus, in the modelling of firm exit decisions, it is essential to include the impacts of spatial correlation to understand factors that explain firm exit. In our case, if these are ignored, the statistical results are ambiguous. The structure of the baking industry and the spatial component in particular provide a useful contrast to earlier empirical analysis that analyses determinants of firm exit.

## V. Conclusion

The analysis of economic activity with time series data is abundant in the literature, whereas spatial analyses of economic activity and decisions are less common. An important measure of economic activity is firm exit. Factors that contribute to explaining firm exit are plant size, firm market share, the number of plants the firm owns, firm diversification, the age of the plant and financial characteristics of the firm. To date, models of firm exit have largely ignored spatial correlation. This article estimates the probability of a firm exiting using a bakery data and provides new insights on the economics and statistical modelling of spatial factors that explain firm exit. The article, in particular, modelled spatial correlation in a dichotomous dependent variable model of firm exit, tested factors that contribute to firm exit with plant level data and evaluated the relation of inter-firm competition when firms exit an industry.

In our application, the importance of spatial correlation from firm competition in the model is striking. Without inclusion of spatial correlation only one out of 10 coefficients is significant, while six of these coefficients become significant when including spatial correlation and this estimates indicate important qualitative relations between firm exit and firms and market characteristics.

Inclusion of the spatial correlation improves the statistical significance of various factors in the probability of exit. Both firm size and product fragmentation reduce the probability of firm exit. Interestingly, firms that face less competition are more likely to succeed, whereas firms in the western USA are less likely to exit. Bread manufacturing is more risky relative to other bakery products due to perishability. In our results, the most important element that explains firm exit, however, is the spatial dichotomous lagged dependent variable. When a competing firm exits, it follows that the probability that the competing firm still in the market faces higher probability of exit.

In relation to previous work, results are consistent with the shakeout theory (Lieberman, 1990) where smaller firms are more likely to exit and this qualitative result is consistent with results by Deily (1991) and Anderson *et al*. (1998), but differ from Schary (1991) on the relation between firm exit and plant size. The model in this article illustrates that inclusion of a spatial lagged dichotomous variable is the most important factor explaining firm exit decisions. Future work should further develop the implications of modelling spatial correlation in discrete choice modelling and its implication on validation of hypotheses and evaluate the importance of location in firm exiting decision for other industries.

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