# Firm Birth and Death in U.S. Manufacturing:
# A Regional Adjustment Model

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**Abstract**

Attracting manufacturing investment is a frequently used rural development policy. Previous research in the location literature has informed policymakers which factors are most important for attracting new firm investment. Far less is known about the interaction of birth and death of establishments. A conceptual model of county-level investment in the U.S. manufacturing sector is developed from location theory and subsequent literature. Specifically, we test the relative importance of location factors influencing firm investment, and if these factors influence firm birth and death differently. Local factors include agglomeration due to localization, urbanization, and internal economies, market structure, labor quality, availability, and cost, market conditions, , infrastructure, and fiscal policy. This study covers the time period 2000 to 2004 for U.S. counties in the lower 48 states. Counts of establishments are from the U.S. Census Bureau's Dynamic Firm Data Series, which links establishments across space and time. Negative binomial models containing spatially lagged endogenous variables are estimated in a regional adjustment framework to show how *ceteris paribus* changes in location factors affect the conditional number of establishment births and deaths in a county.

**Key words:** location determinants, manufacturing, count models
**JEL Codes:** L60, R11, R12

## 1. Introduction

The United States economy has experienced three recessions since the 1980s. Since the late 1990's rural areas in the United States have struggled as manufacturing investment flowed back to urban areas providing access to skilled labor, business services, and product and input markets. Concentration of manufacturing investment in urban areas increased because of the heightened importance of a skilled workforce, supply-chain logistics, and emphasis on scale economies. Related with the cost minimization logic of the new economy is access to deeper labor markets, encouraging manufacturers to seek low-wage workers abroad. To the extent that technological innovation and information technologies drive productivity growth, many rural places are now at a disadvantage with respect to attracting manufacturing investment. Regions hardest hit by these recessions were the heartland states, including Illinois, Ohio, Indiana, Michigan, and Wisconsin. With each downturn in the economy, entry and exit of manufacturing firms is likely to occur more frequently as a consequence of Schumpeter's idea of "creative destruction". The magnitude of destruction may depend on local conditions, previous economic performance, and linkages to a wider, regional context.

The extent to which exiting firms and industry are followed by new establishments will also be influenced by local and regional economic and demographic determinants. The empirical literature documents many examples of firm behavior with respect to entry-exit dynamics even within narrowly defined industries (Bartelsman et al., 2003). Firms enter and exit markets every year. Among entering firms, many fail to survive during the first years while others grow rapidly. Even in expanding industries many firms decline. Firms may enjoy rapid expansion even in contracting industries. As a consequence, changes in employment due to plant openings and closings are as important as changes due to expansions and contractions in surviving firms (Hamermesh, 1993). This empirical result has important implications for policy-makers who offer incentives to attract manufacturing investment.

Economic theory offers some explanations of these stylized facts. Theories arising from Schumpeter's process of creative destruction (e.g., Aghion and Howitt, 1992) suggest that new technologies and innovations are introduced by new firms, which, if successful, replace incumbent firms. Active and passive learning models (e.g., Jovanovic, 1982; Ericson and Pakes, 1995) explain how experimentation under uncertainty about the demand for new products or the cost effectiveness of alternative technologies creates micro-level heterogeneity and firm dynamics. The product life cycle model argues that in a given industry the number of firms and their average size change as a product moves from the development stage to mass production (Ahn, 2001).

This paper investigates the importance of location factors on manufacturing establishment birth and death in U.S., 2000 - 2005. This information will provide policymakers with a better understanding of the interrelationship between firm birth and firm death in light of regional development policies designed to attract or retain manufacturing investment.

## 2. Research Background

The importance of firm birth and death as determinants of market performance is the most frequent reason given for undertaking research in this area. Schumpeter's (1942) theory of "creative destruction" is a cornerstone of this logic. Schumpeter's theory maintains that the vitality of an economic engine in a capitalist society crucially depends on the formation of new goods and services, new methods of production or transportation, new forms of industrial organization, and new markets. Schumpeter emphasized that firm formation via entrepreneurs is crucial in revolutionizing "the pattern of production by exploiting an invention or, more generally, an untried technological possibility for producing a new commodity or producing an old one in a new way…" (Schumpeter, 1942).

Theoretical and empirical studies following Schumpeter's notion provided context for understanding the empirical evidence explaining the creative destruction process observed in firm birth and death (e.g., Dixit, 1992; Ericson and Pakes, 1995, Schapiro and Khemani, 1987; Dunne et al., 1988; Love, 1996; Bernard and Jensen, 2007). Firm entry creates a competitive environment where production costs are minimized. Firm birth and death is indicative of free market entry and exit absent market power. New firms also increase the possibility of product and process innovation (Love, 1996). More generally, firm birth is one means of reallocating resources to their most efficient use as economic conditions change over time.

There are well-established theoretical links between firm birth and death, and the empirical evidence suggests that spatial variations in the two phenomena are highly correlated (Evans and Siegfried, 1992; Love, 1996; Fotopoulos and Spence, 1998; Bruce et al., 2007). A healthy rate of firm births is frequently regarded as a positive indicator of vitality and growth in the spatial economy (Love, 1996). Firm death is also an important catalyst by which resources are redistributed. Moreover, high correlation between firm entry-exit (e.g., turnover) is indicative of a “creative destruction” process hypothesized to promote economic growth. This paper examines the relevant theoretical and empirical literature on aspects of firm birth and death, and develops an empirical model to explain the influence of the creative destructive process of firm entry-exit on the growth and decline of manufacturing establishments between 2000 - 2004.

**Birth Leading to Death**

Firm birth and death are simultaneously determined, but both are influenced by changes in demand or factor prices (Amir and Lambson, 2003). The main link between firm birth and death is found in the industrial organization literature, which frequently cites a positive correlation between establishment entry and exit across industries (Shapiro and Khemani, 1987; Dunne and Roberts, 1991; Evans and Siegfried, 1992). At least two common explanations have been cited in the literature for the positive correlation between firm birth and death. The first is that the likelihood of firm death is inversely related to its age (Dunne et al., 1988; Philips and Kirchhoff, 1989; Bernard and Jenson, 2007). The implication of this relationship is that regions with more firm births can expect to have more firm deaths. The second commonly cited reason for the positive correlation between firm birth and death is that the likelihood of survival is related to firm size (Hall, 1987; Audretsch, 1990; Bernard and Jensen, 2007). All firm births will eventually lead to their demise. The empirical evidence indicates that many new firms very quickly become dead firms, and that this relationship generally holds across countries and business cycles. Over a typical five-year period, more than 30% of U.S. manufacturing plants shutdown (Bernard and Jensen, 2007).

**Death Leading to Birth**

The industrial organization literature involving firm entry and exit contains a common hypothesis that firm births are caused by firm deaths. Replacement and resource release are two reasons given in the literature for this relationship. The replacement argument is used by Austin and Rosenbaum (1990) and Evans and Siegfried (1992) when describing the patterns of birth and death in U.S. manufacturing. New firms may choose to locate where firms died because due physical assets, such as second-hand equipment, will be cheap and available where firm death rates are high. This notion is referred to as the "release hypothesis" (Storey and Jones, 1987).

Despite the mechanism connecting birth to death, the potential effect of death on birth is not clear. The very act of firm birth guarantees at some point in the near or distant future the same firm will die, but firm death is not a necessary or sufficient condition leading to establishment birth. This has implications for the design and estimation of conceptual model described in the next section.

## 3. Econometric Model

Shapiro and Khemani (1987) investigated the interdependence between entry (birth) and exit (death) of manufacturing firms. Their birth/death equations did not contain the same covariates. They used Seemingly Unrelated Regression (SUR) to allow for residuals correlation across equations. Audretsch and Fritsch (1992) looked at birth and death in isolation of each other. One drawback of this approach is that the factors influencing firm birth are assumed to be identical for firm death. Evans and Siegfried (1992) argue that imposing symmetry may distort the true underlying relationship between firm entry and exit. Love (1996) used an equation system to model establishment birth and death. Love's approach seems preferable because it allows for direct tests for feedback between firm entry-exit behavior.

The empirical research to date does not provide clear evidence of the underling processes of the endogenous birth and death in manufacturing industries. Moreover, the literature points to two different hypotheses about the high positive correlation observed between birth and death in manufacturing industries. The first hypothesis suggests that firm birth and death occur simultaneously, with feedback between firm entry and exit. High levels of birth may lead to the displacement of existing firms by new entrants, and hence lead to death. But also high levels of death may create room for more births to take place. The second hypothesis is that of natural churning, which states that higher industry turbulence is due to underlying business conditions. Firm birth and death may be highly positively correlated in time across industries, but the 'causality' is not identifiable as the concept of churning is broader than that of the displacement-vacuum effect which states that exit makes room for entry (Fotopoulos and Spence, 1998).

This study applies a regional adjustment model commonly used to understand population-employment dynamics. The regional adjustment model used here models firm birth and death as an adjustment toward some unknown future state of spatial equilibrium. Assuming equilibrium is reached, all manufacturing firms would be distributed across space in such a way that their profits were maximized with respect to location. Given that this state is unlikely, researchers routinely describe the spatial economy as being in partial equilibrium (Carruthers and Mulligan, 2007). This constant adjustment in firms entering and exiting markets lends itself well the previously discussed notion of Schumpeter's creative destruction.

The process of constant adjustment is often illustrated in regional adjustment models by a system of two simultaneous equations (Steinnes and Fisher, 1974; Carlino and Mills, 1987; Boarnet, 1994a,b; Clark and Murphy, 1996; Carruthers and Vias, 2005; Carruthers and Mulligan, 2007). The adjustment model used here replaces population and employment growth with establishment births and deaths. The adjustment process is given by the following expression:

(1a) $$\mathrm{b}_{i,t} = \alpha_0 + \alpha_1 \mathrm{d}_{i,t-k} + \alpha_2 \mathrm{b}_{i,t-k} + \alpha_3 \mathrm{d}_{i,t} + \theta_b' \mathbf{x}_{i,t-k} + \varepsilon_{i,t}^{b},$$

(1b) $$\mathrm{d}_{i,t} = \beta_0 + \beta_1 \mathrm{b}_{i,t-k} + \beta_2 \mathrm{d}_{i,t-k} + \beta_3 \mathrm{d}_{i,t} + \theta_d' \mathbf{x}_{i,t-k} + \varepsilon_{i,t}^{d},$$

where $t$ is a time period, $k$ is a time lag, and $\theta$ are parameters from location factors hypothesized to impact manufacturing establishment birth and death. Endogenous variables $\mathrm{d}_{i,t}$ and $\mathrm{b}_{i,t}$ appear in the birth and death equations respectively. Equations (1a) and (1b) are estimated with 2SLS conditional on the adjustment variables ($\mathrm{d}_{i,t-k}$ and $\mathrm{b}_{i,t-k}$) and variables controlling for local investment determinants. In the present study $t$ measures the period 2000-2004, i.e., $\mathrm{b}_{i,00\text{-}04}$.

The present framework allows for the incorporation of a conceptual model of location determinants established in previous research (e.g. Bartik,1989; Woodward,1992; Henderson and McNamara,1997; and Lambert et al., 2006a,b) as well as the potential links between birth and death. The location choice for manufacturing investment is $\mathbf{x}_i = \mathrm{h}(\mathrm{A}_i, \mathrm{S}_i, \mathrm{L}_i, \mathrm{I}_i, \mathrm{F}_{i_i})$, where $i$ indexes the choice set, and A, S, L, I, and F are vectors of location attributes corresponding to agglomeration forces (*A*), market structure (*S*), labor (*L*), infrastructure (*I*), and fiscal (*F*) factors that influence a firm's cost structure. No restrictions are made on the exact form of *h*, except that the firm is assumed to minimize total costs. Location determinants are hypothesized to effect birth and death in two ways via firm birth and death in the previous period as well as the stock of firms in each county. Firm location decisions are also likely to be spatially dependent in nature. We now discuss a proposed spatial econometric method for dealing with spatial dependence in count data.

### Linear Spatial Autoregressive Lag Model (SAR)

Whittle (1954) described a class of spatial process models where interactions between neighbors are modeled as a weighted average of nearby cross–sectional units. The endogenous variable comprising the interactions is referred to as a spatially lagged variable. The linear spatial autoregressive lag model (SAR) is $\mathbf{y} = \rho\mathbf{W}\mathbf{y} + \mathbf{X}\boldsymbol{\beta} + \mathbf{u}$, $\mathbf{u} \sim \text{iid}(\mathbf{0}, \boldsymbol{\Omega})$, where $\rho$ is an autoregressive parameter, $\mathbf{W}$ is an $N$ by $N$ exogenous row-standardized matrix defining relationships between spatial units, and $E[\mathbf{u}\mathbf{u}'] = \boldsymbol{\Omega}$ (Anselin and Florax, 1995).[1] The reduced–form version is $\mathbf{y}=\mathbf{A}^{-1}\mathbf{X}\boldsymbol{\beta} + \mathbf{A}^{-1}\mathbf{u}$, with $\mathbf{A} = (\mathbf{I} - \rho\mathbf{W})$, $\mathbf{A}^{-1}$, a "Leontief inverse" matrix (Anselin, 2002), and $\mathbf{I}$ a conformable identity matrix. The inverted matrix relays feedback effects between locations, thereby distinguishing this class of models from other econometric models. We extend this model to count processes. Equations 1a and 1b are modified to include endogenous spatially lagged death and birth as shown by:

(2a) $$\text{b}_{i,t} = \alpha_0 + \alpha_1 \text{d}_{i,t-k} + \alpha_2 \text{b}_{i,t-k} + \rho_1 \mathbf{W}\text{d}_{i,t} + \theta_b' \mathbf{x}_{i,t-k} + \varepsilon_{i,t}^{b},$$

(2b) $$\text{d}_{i,t} = \beta_0 + \beta_1 \text{b}_{i,t-k} + \beta_2 \text{d}_{i,t-k} + \rho_2 \mathbf{W}\text{b}_{i,t} + \theta_d' \mathbf{x}_{i,t-k} + \varepsilon_{i,t}^{d}.$$

[1] Whittle's SAR model was popularized and extended by Cliff and Ord (1981), who further developed models in which the disturbances followed a spatial autoregressive process. The count regression formulation of the error process model is not considered here.

**Multiplicative SAR-AR Negative Binomial Model**

The SAR-AR NBM model suggested here builds on previous work estimating NB models with temporally lagged counts. By convention, we assume an expected outcome at location $i$ = 1,…, $N$ is represented by the inverse of the logarithmic canonical link function, $\mu_i = \exp(\boldsymbol{\beta}'\mathbf{x}_i)$ (Cameron and Trivedi, 1998).

A natural temporal autoregressive model (AR) model for count responses specifies a multiplicative relationship between the lagged count variable and future outcomes, $\mu_t = \exp(\boldsymbol{\beta}'\mathbf{x}_t)y_{t-1}^{\rho}$ (Cameron and Trivedi, 1998). The first approach to overcome the obvious problem of zero counts adds a small constant to the lagged outcome variable, such that $y_{t-1}^{*}$ = max{$c$, $y_{t-1}$}, $0 < c \leq 1$. The second approach estimates simultaneously the value of the constant ($c$) with the model parameters (Zeger and Qaqish, 1988), suggesting the AR model,

(3) $\mu_t = \exp(\boldsymbol{\beta}'\mathbf{x}_t + \rho \ln y_{t-1}^{*} + c^{*} d_{t-1})$, $d_{t-1}$ = 1 if $y_{t-1}$ = 0, 0 otherwise, $c = \exp(c^{*}/\rho)$.

Equation 3 can be estimated using ML. The marginal effects and elasticities (η) are calculated as (respectively), $\frac{\partial y_i}{\partial x_{ik}} = \beta_k \cdot \exp(\boldsymbol{\beta}'\mathbf{x}_i) y_{i\,t-1}^{*\rho}$ and $\eta_{ik} = \beta_k \cdot x_{ik}$.

The spatial autoregressive (SAR) analogue of the multiplicative AR model for count data is $\mu_i^{SAR} = \exp(\boldsymbol{\beta}'\mathbf{x}_i)\prod_{j \neq i} y_j^{\rho w_{ij}}$, with $w_{ij}$ the $i$,$j$–th element of **W**. Moving the multiplicative component inside the exponential,

(4a) $\mu_i^{SAR} = E[y_i] = \exp(\rho \sum_{j \neq i} w_{ij} \ln(y_j) + \boldsymbol{\beta}'\mathbf{x}_i)$.

The link between the multiplicative SAR model and its linear cousin is clear by inspection of the reduced form of equation 4a. Taking the natural logarithm of equation 4a,

(4b) $\ln y_i = \rho \sum_{j \neq i} w_{ij} \ln y_j + \boldsymbol{\beta}'\mathbf{x}_i$, or $\ln y_i - \rho \sum_{j \neq i} w_{ij} \ln y_j = \boldsymbol{\beta}'\mathbf{x}_i$.

Equation 3b can be expressed compactly as $\mathbf{y} = \exp(\mathbf{A}^{-1}\mathbf{X}\boldsymbol{\beta})$, with the corresponding mean $\mu_i^{SAR} = \exp(\boldsymbol{\beta}'\mathbf{a}_{i.}^{inv}\mathbf{x}_i)$, where "*i*." represents the *i*th row vector, and $\mathbf{a}_{i.}^{inv}$ the *i*th row vector of $\mathbf{A}^{-1}$. The marginal effects and elasticities ($\eta^{SAR}$) are calculated as (respectively), $(\partial y_i / \partial x_{ik}) = \beta_k \exp(\boldsymbol{\beta}'\mathbf{a}_{i.}^{inv}\mathbf{x}_i)$ and $\eta_{ik}^{SAR} = \beta_k \mathbf{a}_{i.}^{inv} x_{ik}$.

The problem of lagged zero counts is handled as it is with the time series AR analogue. The first option transforms the lagged outcome variable by adding a constant to the outcome variable (i.e., $y_i^* = \ln(y_i + 0.5)$). The second option is to estimate simultaneously the constant with the structural parameters. We choose to use the first option as a preliminary step. A two-step procedure suggested by Murphy and Topel (1985) is used to obtain consistent standard errors of the SAR-AR NBM estimates.

**Two-step Estimation of the SAR-AR Count Model**

There are numerous examples where endogenous parameters are estimated using two-step procedures (e.g., Murphy and Topel, 1985; Greene, 2003). We motivate the two-step SAR count model assuming the transformation constant is estimated following Cameron and Trivedi (1998).

Given the endogeneity of $\mathbf{w}_{i.}\ln\mathbf{y}^*$, the first stage model and corresponding likelihood function is,

(5a) $E[\mathbf{W}\ln\mathbf{y}^*, \mathbf{q}; \boldsymbol{\theta}_1]$, $\ln L_1 = \sum^{n}_{i=1} f_1(\mathbf{w}_{i.}\ln\mathbf{y}^* | \mathbf{q}_i, \boldsymbol{\theta}_1, \alpha_1)$, and

where $\alpha_1$ is the dispersion parameter from the first stage estimation, the instruments ($\mathbf{q}$) include the exogenous variables, and the linear spatial lags of the exogenous variables; $\mathbf{q} = [\mathbf{x}, \mathbf{Wx}]$ (Anselin, 1988).

Equation 4 is linear and can be estimated with ordinary least squares, with the usual heteroskedastic-robust covariance estimator $\mathbf{V}_1[\hat{\boldsymbol{\theta}}_1] = (\mathbf{q}'\mathbf{q})^{-1}\mathbf{q}'\boldsymbol{\Omega}_1\mathbf{q}(\mathbf{q}'\mathbf{q})^{-1}$. The diagonal elements of $\boldsymbol{\Omega}_1$ are the squares of the residuals, $\hat{u}_{1i} = \mathbf{w}_{i.}\ln(\mathbf{y}^*) - \hat{\boldsymbol{\theta}}_1'\mathbf{q}_i$, with zeros in the off-diagonal elements. The gradient of $\ln L_1$ is $\mathbf{g}_1 = \mathbf{q}'\hat{\mathbf{u}}_1$.

The second stage NBM model is,

(5b) $E[\mathbf{y}, \mathbf{X}^*; \boldsymbol{\theta}_3, \rho, c, \alpha_2]$,

where $\mathbf{X}^*$ contains exogenous variables and the predicted values of the first stage estimation. The lag spatial autoregressive parameter is $\rho$. Given consistent estimates of $(\boldsymbol{\theta}_1, \boldsymbol{\theta}_2)$, 4b can be estimated with maximum likelihood. The maximum likelihood objective for the second stage is,

(6) $\ln L_2 = \sum_{i=1}^{n} f_2(y_i|\mathbf{x}_i, \boldsymbol{\theta}_2, \rho, c, \alpha_2, (\mathbf{w}_{i.}\ln\mathbf{y}|\mathbf{q}_i, \hat{\boldsymbol{\theta}}_1))$,

with the gradient $\mathbf{g}_2 = \mathbf{X}^{*\prime}\hat{\mathbf{u}}_2$ , $\hat{u}_{2i} = [y_i - \hat{\boldsymbol{\theta}}_2'\mathbf{x}_i - \hat{\rho}\,(\hat{\boldsymbol{\theta}}_1'\mathbf{q}_i)]$. The second stage estimators $(\boldsymbol{\theta}_2, \rho)$ are consistent if the regularity conditions are met for models 5a (Greene, 2003). The distribution of the parameters in (6) is consistent and asymptotically (*Asy*) normal with covariance,

(7) $\mathbf{V}_2^* = \mathbf{V}_2 + \mathbf{V}_2[\mathbf{C}_{12}\mathbf{V}_1\mathbf{C}_{12}' - \mathbf{R}_{12}\mathbf{V}_1\mathbf{C}_{12}' - \mathbf{C}_{12}\mathbf{V}_1\mathbf{R}_{12}']\mathbf{V}_2$ ,

where $\mathbf{V}_2 = AsyVar[\hat{\boldsymbol{\theta}}_2, \hat{\rho}, c, \alpha_2]$ from $L_2$ (Murphy and Topel, 1985).

The **C** and **R** matrices adjust the second stage covariance matrix by including the covariance between the first stage gradients and the second stage likelihood function (Greene, 2003),

(8a) $\mathbf{R}_{12} = E[(\partial \ln L_2/\partial(\boldsymbol{\theta}_2, \rho, c, \alpha_2))(\partial \ln L_1/\partial\boldsymbol{\theta}_1')] = \mathbf{g}_2\mathbf{g}_1'$,

(8b) $\mathbf{C}_{12} = E[(\partial \ln L_2/\partial(\boldsymbol{\theta}_2, \rho, c, \alpha_2))(\partial \ln L_2/\partial\boldsymbol{\theta}_1')] = \mathbf{g}_2\tilde{\mathbf{q}}_1'$, $\tilde{\mathbf{q}}_1' = \hat{\rho}\,\mathbf{q}'\hat{\mathbf{u}}_2$.

The transformation results in consistent and heteroskedastic robust standard errors. The entire procedure is conducted for to obtain estimates for equations 2a and 2b.

**4. Data**

County level manufacturing data are from the U.S. Census Bureau's Dynamic Firm Data Series, which is compiled as part of Statistics of U.S. Businesses (SUSB). The longitudinal data series links establishments across space and time and distinguishes between single and multi–unit establishments. The Census Bureau defines an establishment as a single physical plant location where industrial operations are performed (U.S. Census Bureau, 2008). Firms are considered to be business organizations consisting of one or more domestic establishments in the same state and industry that were specified under common ownership or control. The definition of firm and establishment is synonymous with single–establishment firms. Establishments are linked from year to year by the business information tracking series (BITS) and annual County Business Patterns (CPB). These links ensure that firms that emerge after change ownership or other organizational changes are not counted as births. From this file, the SUSB creates longitudinal tabulations at the firm level to obtain a count of firms at the county level.

Counts of single unit establishment births and deaths are used to compare the importance of location factors over the 2000–2004 period. Birth is defined as an establishment that has zero employment in the first quarter of the previous year and positive employment in the first quarter of year $t$. Firm deaths are firms that had employed workers in the first quarter of year $t$–1 and zero employment in the first quarter of the subsequent year.[2]

Agglomeration ($A$) economies are important factors in firms' location decisions (Coughlin et al., 1991; Woodward, 1992). Agglomeration is measured in 2000 levels by the percentage of manufacturing establishments with less than 10 employees, manufacturing's share

[2] Using birth and death rates can be used mitigate to some extent scaling issues and potential heteroskedasticity caused by differences in areal unit size (Storey and Johnson, 1987; Audretsch and Fritsch, 1992; Love, 1996; Fotopoulos and Spence, 1998).

of employment in a county, percentage of manufacturing establishments with more than 100 employees, and total business establishment density scaled by area. The first two measures are proxies for local agglomeration economies. The third and fourth measures are intended to capture economies of scale internal to the firm and urbanization economies respectively. All four measures are hypothesized to have a positive impact on firm location choice, and thus result in higher incidence of birth and death in a county. A stock measure of manufacturing establishments is used to control for size effects. Sector–specific employment data are from the U.S. Department of Transportation commuting patterns compiled by Research and Innovation Technology Administration (RITA). Total firm density and percentage of manufacturing establishments with less than 10 and more than 100 employees are calculated from the annual CBP files.

Market structure (*S*) is often the most important factor in investment location decisions (Blair and Premus, 1987; Crone, 1997). A county with more wealth and people increases the likelihood that it is a demand center for goods and services. Demand markets may also harbor a relatively larger stock of creative individuals capable of solving difficult supply issues or combining old ideas in a novel ways, which may stimulate establishment birth firm formation (Wojan and McGranahan, 2007). Median household income, population, and the share of workers in creative occupations[3] are used to measure the market structure of a county.

Labor (*L*) availability and cost are measured by (respectively) county unemployment rates (Bureau of Labor Statistics, BLS) and average wage per job (from the BEA). A high unemployment rate is hypothesized to attract manufacturing investment, whereas a high average

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[2]The creative class share of employment was constructed by McGranahan and Wojan (2007) is available at http://www.ers.usda.gov/Data/CreativeClassCodes/.

wage per job increases labor costs, deterring investment. Additionally, labor skill is measured by the percentage of a county's population 25 years of age and older with an associate's degree. Labor may also be sourced from neighboring counties. Net flows of wages per commuter between place of residence and place of work help identify counties that are sources or sinks of labor.

Access to and breadth of infrastructure (*I*) measure by density of public roads and miles of interstate highway with data from the Department of Transportation (DOT). Infrastructure quality is measured by per capita local government expenditures on highways (Census of Governments, 1997). Available land is measured as the percentage of a county's total area in farmland, which is hypothesized to attract investment as the availability of land increases. Presumably, farmland may be converted for other uses. This measure is calculated using a GIS database ArcGIS 9.2 by ESRI. For some counties, farmland area was not disclosed due to the small number of farms. In those cases, this value was approximated by multiplying the number of farms by the average farm size measured in acres.

Fiscal (*F*) policy may impact the cost of conducting business in a region. Local governments walk a fine line between generating sufficient revenue to provide public goods and services, and supporting a favorable business climate (Gabe and Bell, 2004). Firms may consider other locations if tax rates are too high. Taxes may deter manufacturing investment (Wheat, 1986; Bartik, 1989), but local spending a benefit (Goetz, 1997). Obtaining detailed tax information at the county level is difficult. We use a composite measure of tax burden called the state tax business climate index (Hodge et al., 2003).[4] Higher index values indicate more

[4] The tax business climate index is only available at the state level and with the earliest year reported in 2002. While a measure in 2000 would be preferred, the measures reported in subsequent years show that the index remains stable across time.

favorable business climates. Government expenditures on education per capita measure the level of public good services provided by local governments.

Presence of cities may have additional impacts on location choice beyond urbanization and agglomeration economies. Dummy variables are included in the model to account for counties belonging to metropolitan and micropolitan statistical areas (MSA) as defined by the BEA. Counties not belonging to these two groups are classified as ‘non-core’. These variables will pick up any unmodeled differences between metro and micropolitan areas. Metro and micropolitan counties are hypothesized to have a locational advantage compared to non-core counties.

<< Insert Table 1>>

## 5. Empirical Results

The empirical analysis applies a regional adjustment model to explain establishment births and deaths between 2000 to 2004 period while using 2000 as the base year. Table 2 shows the model results from a standard negative binomial model (NBM), first stage estimation of the birth and death process using **X** and cross-regressive terms (**WX**) to instrument out the endogenous death and birth, and second stage estimation using a Murphy and Topel (1985) procedure to obtain consistent standard errors across the two stages. Results from the NBM second stage show that the coefficients on the endogenous variables ($d_{00\text{-}04}$ and $b_{00\text{-}04}$) are negatively correlated with birth and death processes respectively. This is likely due to the macroeconomic recession of 2000 – 2001. Model results are similar across the NBM and second stage NBM. Initial births and deaths are only significant in the birth process. The local agglomeration measures show positive effects on births and deaths in a county. However, urban and internal agglomeration economies act as deterrents. All of the market structure measures reveal a positive association with establishment births and deaths. Availability and skill of labor are also positively correlated, but average wages per job and the net flow of wages per commuter have a negative correlation with births and deaths. The latter measure suggests that manufacturing firms may prefer source counties of labor versus sink counties ceterus paribus. Infrastructure factors with the exception of available land are positively associated with higher counts of births and deaths. The fiscal measures are not significant with the exception of the business tax climate index, which has a positive and significant coefficient.

<< Insert Table 2 >>

The cross-regressive terms in the first stage model provide further insight on the effect of localized spillovers from the location determinants. For a particular county, its neighboring counties' agglomeration factors help attract more establishment births and deaths, but neighboring Interstate infrastructure reduces the conditional number of births and deaths. Similarly, neighboring counties' which have a higher business tax climate index reduce the conditional number of establishment births.

**Spatial Autoregressive NBM Results**

Marginal effects and elasticities in count models depend on the values of the other explanatory variables (Winkelmann, 2008). Moreover, results from models containing spatially lagged dependent variables carry unique information due to the nature of the spatial multiplier, $(\mathbf{I} - \rho\mathbf{W})^{-1}$ (Abreu et al., 2005; LeSage and Pace, 2009). Combining these properties, the marginal effects and elasticities for the spatial NBMs ($\eta^{SAR}$) are calculated as (respectively), $(\partial y_i / \partial x_{ik}) = \beta_k \exp(\boldsymbol{\beta}'\mathbf{a}_{i.}^{inv}\mathbf{x}_i)$ and $\eta_{ik}^{SAR} = \beta_k \mathbf{a}_{i.}^{inv} x_{ik}$ . The impact on the dependent variable from a change in a covariate can be summarized in the three ways (Abreu et al. 2005; Pace and LeSage, 2007). The first is the average total effect on an observation. The row sums represent the total effect on each observation from changing the *k*th explanatory by the same amount across all observations. Dividing the row sums by the number of observations yields the average total effects. The second impact is referred to as the average direct effect, which is the effect of changes in the *i*th observation of $x_k$ on $y_i$. It is measured by stripping out the trace of the *N* by *N* matrix containing $\eta^{SAR}$ and dividing by the number of observations. The third impact is referred to as the indirect effect, which arises as a result of feedback effects through neighbors, and back to the observation that received a direct impact.

<< Insert Table 3 >>

The spatial autoregressive terms are positive and statistically significant in both the birth ($\rho_1$ = 0.06) and death ($\rho_2$=0.08) equations. Table 3 reports the average direct and indirect effects in elasticity form for establishment births and deaths. The elasticities are similar in sign and magnitude across the equations. We interpret this as a barrier to entry also acts as a barrier to exit. Results show that as local agglomeration economies increase, establishment birth and death increase. Urban and internal agglomeration economies have the opposite effect perhaps suggesting diseconomies due to congestion and competition. A percentage increase in the number of establishments with more than 100 employees (pemt100) decreases establishment births and deaths by -0.73% and -0.91%. Market structure elasticities indicate that more demand and wealth lead to more births and deaths. A one percent increase in a county's median household income (mhhi) and its neighbors' (mhhi) increases the conditional number of establishment births by 1.45% (1.367 + 0.086) and deaths by 1.27%.

Manufacturing establishment births and deaths appear to respond the most to changes in median household income, with an elasticity greater than one. An increase in the availability and skill of labor also increases the conditional number of births and deaths in a county. On average, increasing the percentage of the adult population in a county who possess an associate's degree increases the number of births and deaths by 0.25% and 0.27% respectively. However, a one percent increase in average wages reduces the births and deaths by around 0.6%. Changes in infrastructure also have positive elasticities with the exception of available land. The results on fiscal determinants are somewhat mixed with increases in the business tax climate index and government education expenditures per capita being positive, but government expenditures on highways per capita being negative. Switching from a non-core to a metropolitan county increases the number of births and deaths by around 0.3%. The same is true for micropolitan counties, but smaller in magnitude.

**Spillovers from Metro to Non-metro Counties**

Policymakers and economic development practitioners may be interested in knowing how such changes in metropolitan counties spillover to non-metro counties. We set up a series of policy scenarios where the levels of selected variables are increased by 2% in metropolitan counties. We focus on the birth process, although the results would hold similar for death. Figure 1 shows how agglomeration growth in metro counties spills into non-metro counties impacting establishment births. Non-metro counties in the Midwest and the South appear to benefit the most from agglomeration spillovers as shown by the low-high category of the map.

Figures 2 and 3 show results of how changes to the percentage of manufacturing establishments with more than one hundred employees and to the percentage with less than ten employees in metro counties spillover to non-metro counties. Non-metro counties in the Great Plains capture a higher spillover from firms possessing internal economies of scale. The opposite effect is observed from spillovers of increasing small firms. There the effect is limited to non-metro counties immediately surrounding metro areas. Lastly, Figure 4 shows the impact on establishment births from spillovers from metro to non-metro counties by increasing the percentage of adults holding an associate's degree. Several significant low-high clusters appear in New York, central Florida, northern Illinois, central Michigan, California, Arizona, and the Pacific Northwest.

## 6. Conclusions

This research contributes to the empirical literature examining manufacturing establishment birth and death using a regional adjustment model. A system of negative binomial equations is estimated containing endogenous spatially lagged variables. Results show that factors which are positively/negatively associated with birth are also positively/negatively associated with death. This finding is consistent with previous results in the literature suggesting that barriers to entry are also barriers to exit. Market demand remains one of the strongest location factors in explain manufacturing establishment birth and death.

We construct a series of policy scenarios showing how establishment births in non-metro counties are impacted by spillovers from changes in metropolitan counties attributes. Non-metro counties in the Midwest and Northeast appear to gain most of the spillovers from metro counties. We find this to be especially the case for changes in educational attainment.

Much remains to be done with respect to estimating Poisson of negative binomial regressions with lagged dependent variables. In this application, a two-step procedure was used that employed a Murphy-Topel covariance estimator to adjust the second stage standard errors. Other estimators are possible in the context, general moment estimators, or possibly direct non-linear estimation procedures.

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Table 1. Descriptive Statistics

| Variables | Label | Average | Stdev | Min | Max |
|---|---|---|---|---|---|
| INDEPENDENT | | | | | |
| Birth$_{2000}$ | $b_{00}$ | 7.30 | 34.89 | 0.00 | 1482.00 |
| Death$_{2000}$ | $d_{00}$ | 8.114 | 39.373 | 0.000 | 1616.000 |
| Manuf. establishments | mestock | 114.66 | 458.00 | 0.00 | 17606.00 |
| Manuf. share of employment (%) | msemp | 15.19 | 10.35 | 0.00 | 63.66 |
| Percent of manuf. establishments with less than 10 emp. | pelt10 | 52.11 | 19.99 | 0.00 | 100.00 |
| Percent of manuf. estlablishments with more than 100 emp. | pemt100 | 11.05 | 9.93 | 0.00 | 100.00 |
| Total establishment density (estab. per square mile) | tfdens | 5.21 | 59.98 | 0.00 | 3191.62 |
| Median household income | mhhi | 35215.04 | 8741.67 | 12692.00 | 82929.00 |
| Population | pop | 91036.68 | 295680.90 | 65.00 | 9545829.00 |
| Creative class share of employment (%) | cclass | 17.18 | 5.94 | 3.88 | 54.07 |
| Unemployment Rate (%) | uer | 4.32 | 1.64 | 1.40 | 17.50 |
| Associate's Degree (% of population 25 years +) | pedas | 5.70 | 1.99 | 0.38 | 15.60 |
| Average wage per job ($) | awage | 24686.17 | 5592.08 | 13673.00 | 74381.00 |
| Net flow of labor earnings per employee ($) | netflow | 1962.72 | 7212.24 | -137906.47 | 143256.42 |
| Public road density | proad | 1.84 | 1.52 | 0.03 | 20.89 |
| Interstate (miles) | interst | 14.68 | 25.23 | 0.00 | 398.31 |
| Available land (% farm area/total area) | avland | 31.29 | 25.96 | 0.00 | 98.24 |
| Business tax climate index | bci | 5.91 | 0.99 | 3.97 | 8.30 |
| Govt. highway expend. per capita ($) | hwypc | 177.48 | 250.04 | 0.00 | 7603.98 |
| Govt. education expend. per capita ($) | educpc | 1184.08 | 1169.93 | 0.00 | 56151.68 |
| Metropolitan county | metro | 0.34 | 0.48 | 0.00 | 1.00 |
| Micropolitan county | micro | 0.22 | 0.41 | 0.00 | 1.00 |
| Non-core county | noncore | 0.44 | 0.50 | 0.00 | 1.00 |
| DEPENDENT (2000 - 2004) | | | | | |
| Firm births | $b_{00-04}$ | 32.84 | 157.52 | 0.00 | 6938.00 |
| Firm deaths | $d_{00-04}$ | 39.94 | 198.72 | 0.00 | 8593.00 |

*N* = 3,078

Table 2. Negative Binomial Models of Manufacturing Births and Deaths

| | NBM | | NBM First Stage Cross-Regression | | NBM Second Stage | |
|---|---|---|---|---|---|---|
| | Birth | Death | Birth | Death | Birth | Death |
| constant | -1.043*** | -1.228*** | -1.817*** | -1.618*** | -0.606*** | -0.846*** |
| $b_{00}$ | 0.019*** | 0.005 | 0.004 | 0.019*** | 0.030*** | 0.012*** |
| $d_{00}$ | -0.017*** | -0.003 | 0.001 | -0.013*** | -0.014*** | 0.002 |
| $b_{00-04}$ | -------- | -------- | -------- | -------- | -------- | -5.5e-10*** |
| $d_{00-04}$ | -------- | -------- | -------- | -------- | -4.5e-10*** | -------- |
| mestock | 1.2e-04 | 7.9e-05 | -3.3e-04 | -2.2e-04 | -1.8e-04 | -1.5e-04 |
| msemp | 0.048*** | 0.053*** | 0.037*** | 0.035*** | 0.039*** | 0.044*** |
| pelt10 | 0.005*** | 0.007*** | 0.008*** | 0.005*** | 0.005*** | 0.008*** |
| pemt100 | -0.018*** | -0.021*** | -0.019*** | -0.016*** | -0.013*** | -0.016*** |
| tfdens | 3.1e-04 | -7.3e-04 | -8.2e-04** | 2.4e-04 | -0.001*** | -0.002*** |
| mhhi | 2.4e-05*** | 1.9e-05*** | 5.1e-06*** | 1.2e-05*** | 3.9e-05*** | 3.4e-05*** |
| pop | 1.7e-06*** | 1.7e-06*** | 1.6e-06*** | 1.6e-06*** | 1.2e-06*** | 1.2e-06*** |
| cclass | 0.079*** | 0.079*** | 0.078*** | 0.077*** | 1.2e-05*** | 1.6e-05*** |
| uer | 0.078*** | 0.090*** | 0.017 | 0.005 | 0.062*** | 0.076*** |
| pedas | 0.045*** | 0.048*** | 0.074*** | 0.062*** | 0.045*** | 0.049*** |
| awage | -3.5e-05*** | -2.5e-05*** | -3.4e-05*** | -4.0e-05*** | -2.3e-05*** | -1.4e-05*** |
| netflow | -1.5e-05*** | -1.4e-05*** | -1.8e-05*** | -1.7e-05*** | -1.5e-05*** | -1.4e-05*** |
| proad | 0.096*** | 0.122*** | 0.104*** | 0.094*** | 0.120*** | 0.149*** |
| interst | 0.005*** | 0.005*** | 0.005*** | 0.005*** | 0.005*** | 0.006*** |
| avland | -0.007*** | -0.007*** | 0.002* | 0.002 | -0.007*** | -0.007*** |
| bci | 0.036** | 0.028** | 0.115*** | 0.085** | 0.562*** | 0.573*** |
| educpc | 3.2e-05 | 3.5e-05 | 3.3e-05*** | 3.2e-05*** | 3.1e-05 | 3.3e-05 |
| hwypc | -2.7e-04 | -3.2e-04 | -2.7e-04*** | -2.5e-04*** | -3.1e-04 | -3.5e-04 |
| metro | 0.830*** | 0.856*** | 0.732*** | 0.725*** | 0.941*** | 0.961*** |
| micro | 0.548*** | 0.590*** | 0.507*** | 0.473*** | 0.607*** | 0.643*** |

Table 2. Continued

| | | | | | | |
|---|---|---|---|---|---|---|
| W × $b_{00}$ | -------- | -------- | 0.008 | 1.9e-04 | -------- | -------- |
| W × $d_{00}$ | -------- | -------- | -0.018*** | -0.009* | -------- | -------- |
| W × mestock | -------- | -------- | 0.001*** | 7.9e-04** | -------- | -------- |
| W × msemp | -------- | -------- | 0.031*** | 0.028*** | -------- | -------- |
| W × pelt10 | -------- | -------- | 0.006*** | 0.007*** | -------- | -------- |
| W × pemt100 | -------- | -------- | -0.010** | -0.010** | -------- | -------- |
| W × tfdens | -------- | -------- | 0.001* | 6.8e-04 | -------- | -------- |
| W × mhhi | -------- | -------- | 3.6e-06 | 5.3e-06 | -------- | -------- |
| W × pop | -------- | -------- | 2.7e-07 | 3.1e-07 | -------- | -------- |
| W × cclass | -------- | -------- | 2.6e-06 | -3.1e-08 | -------- | -------- |
| W × uer | -------- | -------- | 0.090 | 0.094*** | -------- | -------- |
| W × pedas | -------- | -------- | -0.015 | -0.010 | -------- | -------- |
| W × awage | -------- | -------- | 1.8e-05** | 9.4e-06 | -------- | -------- |
| W × netflow | -------- | -------- | 6.0e-06** | 4.4e-06* | -------- | -------- |
| W × proad | -------- | -------- | -0.020 | -0.043 | -------- | -------- |
| W × interst | -------- | -------- | -0.003** | -0.003** | -------- | -------- |
| W × avland | -------- | -------- | -0.010*** | -0.010*** | -------- | -------- |
| W × bci | -------- | -------- | -0.099** | -0.058 | -------- | -------- |
| W × hwypc | -------- | -------- | -1.6e-05 | -1.6e-05 | -------- | -------- |
| W × educpc | -------- | -------- | -2.6e-05 | 1.5e-05 | -------- | -------- |
| W × metro | -------- | -------- | 0.569*** | 0.543*** | -------- | -------- |
| W × micro | -------- | -------- | 0.504*** | 0.507*** | -------- | -------- |
| alpha | 0.428 | 0.438 | 0.384 | 0.383 | 0.429 | 0.438 |
| Log Likelihood | -10373.7 | -10703.1 | -10534.9 | -10242.3 | -10391.9 | -10716.5 |
| Pseudo $R^2$ | 0.203 | 0.205 | 0.213 | 0.217 | 0.803 | 0.814 |

*N* = 3078; ***,**,* represent statistical significance at 1%, 5%, and 10% level respectively.

Table 3. Negative Binomial SAR-AR Elasticities

| | Birth | | Death | |
|---|---|---|---|---|
| | Direct | Indirect | Direct | Indirect |
| $b_{00}$ | 0.217*** | 0.014*** | 0.083*** | 0.007*** |
| $d_{00}$ | -0.109*** | -0.007*** | 0.018*** | 0.001*** |
| $b_{00-04}$ | -------- | -------- | -2.2e-08*** | -1.8e-09*** |
| $d_{00-04}$ | -1.8e-08*** | -1.1e-09*** | -------- | -------- |
| mestock | -0.020*** | -0.001*** | -0.018*** | -0.001*** |
| msemp | 0.590*** | 0.037*** | 0.663*** | 0.054*** |
| pelt10 | 0.286*** | 0.018*** | 0.404*** | 0.033*** |
| pemt100 | -0.687*** | -0.043*** | -0.844*** | -0.068*** |
| tfdens | -0.007*** | -4.5e-04*** | -0.013*** | -0.001*** |
| mhhi | 1.367*** | 0.086*** | 1.170*** | 0.095*** |
| pop | 0.107*** | 0.007*** | 0.109*** | 0.009*** |
| cclass | 4.5e-04*** | 2.9e-05*** | 4.5e-04*** | 3.7e-05*** |
| uer | 0.254*** | 0.016*** | 0.308*** | 0.025*** |
| pedas | 0.240*** | 0.015*** | 0.251*** | 0.020*** |
| awage | -0.593*** | -0.037*** | -0.593*** | -0.048*** |
| netflow | -0.114*** | -0.007*** | -0.114*** | -0.009*** |
| proad | 0.224*** | 0.014*** | 0.279*** | 0.023*** |
| interst | 0.078*** | 0.005*** | 0.083*** | 0.007*** |
| avland | -0.224*** | -0.014*** | -0.215*** | -0.017*** |
| bci | 0.390*** | 0.025*** | 0.397*** | 0.032*** |
| educpc | 0.036*** | 0.002*** | 0.039*** | 0.003*** |
| hwypc | -0.056*** | -0.004*** | -0.065*** | -0.005*** |
| metro | 0.326*** | 0.021*** | 0.333*** | 0.027*** |
| micro | 0.131*** | 0.008*** | 0.138*** | 0.011*** |

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

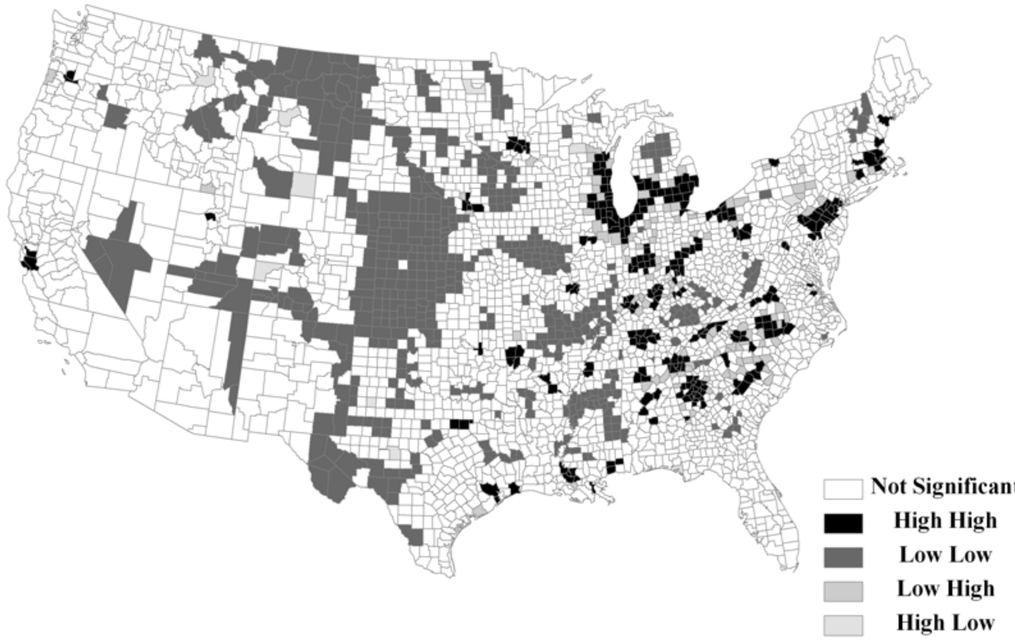


Figure 1. Spillovers from metro to non-metro counties by shocking msemp by 2%

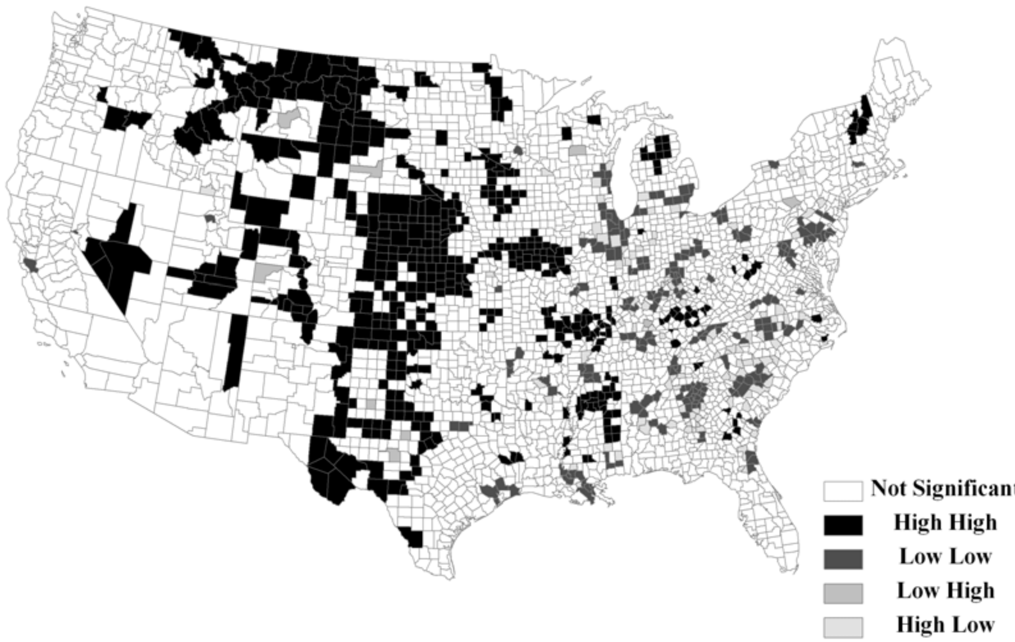


Figure 2. Spillovers from metro to non-metro counties by shocking pemt100 by 2%

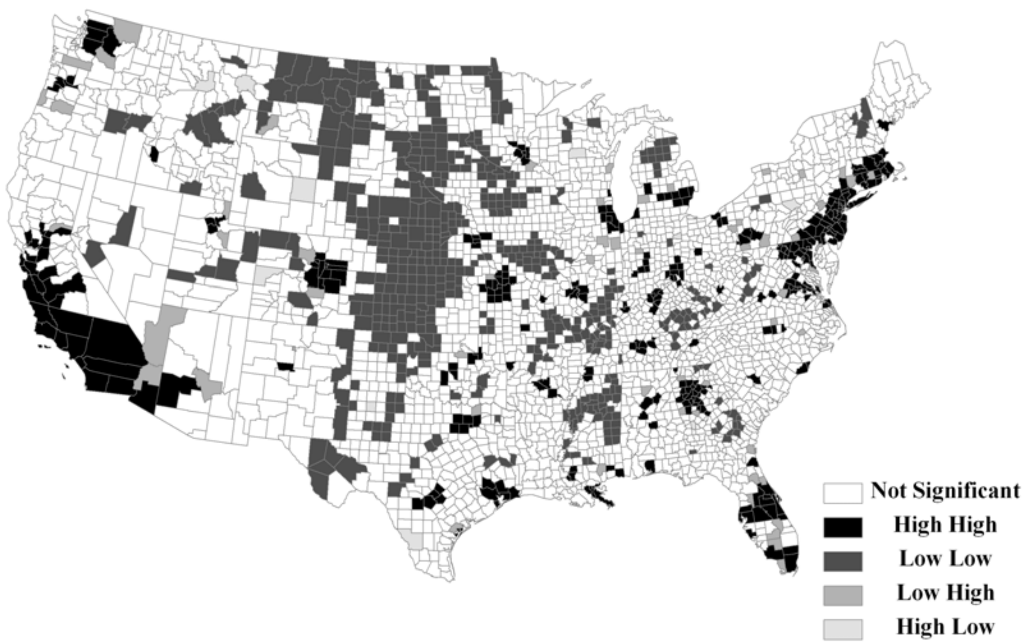


Figure 3. Spillovers from metro to non-metro counties by shocking pelt10 by 2%

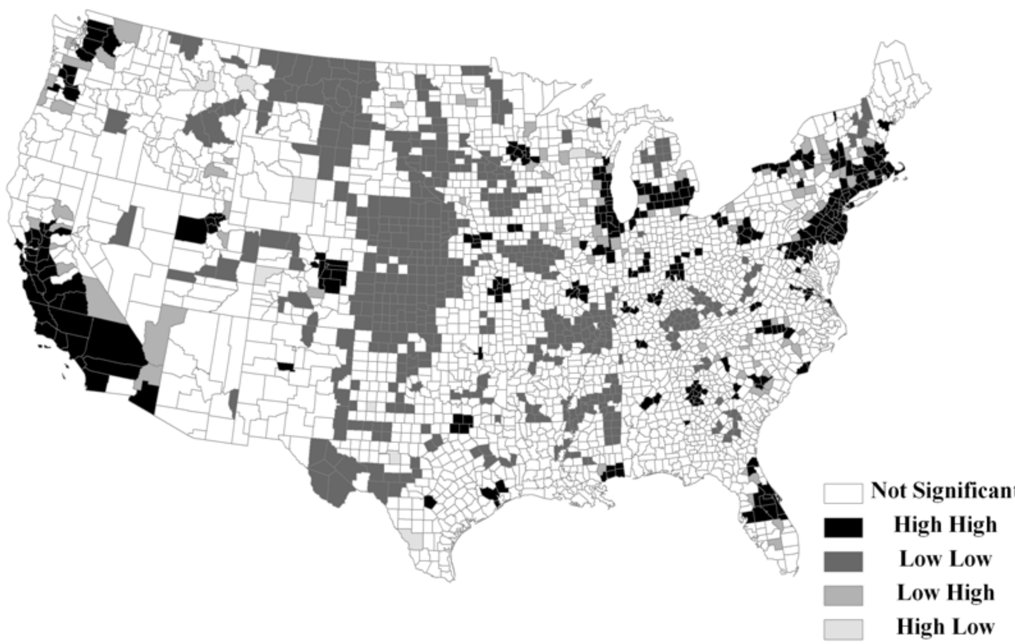


Figure 4. Spillovers from metro to non-metro counties by shocking pedas by 2%