Short-run Birth and Death of U.S. Manufacturing Firms: 2000 - 2005

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Abstract

Attracting manufacturing investment remains a viable regional 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 dynamics of firm death and the possible interaction with firm birth. 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 labor quality, availability, and cost, market conditions, agglomeration due to localization and urbanization economies, infrastructure, and fiscal policy. This study covers the time period 2000 to 2004 for U.S. counties in the lower 48 states. Firm data are from the U.S. Census Bureau's Dynamic Firm Data Series, which links establishments across space and time. Regional adjustment models are used to show how *ceteris paribus* changes in location factors affect the birth and death rates in a county.

Key words: location factors, manufacturing, creative destruction
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 entry and exit in U.S., 2000 - 2005. This information will aid policymakers in 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 - 2005.

2.1 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).

2.2 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 firm birth and death rates. The adjustment process is given by the following expression in reduced form:

$$\Delta b_{i,t} = (b_t - b_{t-k}) = \alpha_0 + \alpha_1 d_{i,t-k} + \alpha_2 b_{i,t-k} + \boldsymbol{a}_3' \boldsymbol{x}_{i,t-k} + \varepsilon_{it} \tag{1a}$$

$$\Delta d_{i,t} = (d_t - d_{t-k}) = \beta_0 + \beta_1 b_{i,t-k} + \beta_2 d_{i,t-k} + \boldsymbol{b}_3' \boldsymbol{x}_{i,t-k} + u_{it}, \tag{1b}$$

where t is a time period, k is a time lag, and ($\boldsymbol{a}$,$\boldsymbol{b}$) are reduced-form parameters from location factors hypothesized to impact birth and death rates. Estimation of the reduced form equations is carried out with seemingly unrelated regressions (SUR). Equations (1a) and (1b) are estimated conditional on the adjustment variables (lagged firm birth and death rates) and variables controlling for local investment determinants.

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 $x_i = h(A,S,L,I,F)$, 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 rates in two ways via firm birth and death in the previous period as well as the stock of firms in each county.

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 firm 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. The counts of births and deaths are then used to estimate birth and death rates by dividing by the stock of manufacturing firms in year *t*. Using birth and death rates 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).

One important consideration is firm type, as location choice and the corresponding birth and death rates are likely to be heterogeneous across firms. While we cannot observe a specific firm in our data, we can observe whether or not a birth (death) is a single-unit or multi-unit establishment. A multi-unit establishment birth belongs to a firm conducting business in another location. In the case of a single-unit birth (death), the terms 'establishment' and 'firm' are interchangeable. Assuming that single-unit firms are more likely to be established by entrepreneurs, differences in constraints can partially be explained by behavioral factors. For example, Figueiredo et al. (2002) found that when investors were faced with location choices inside or outside their residence, some investors were willing to substitute higher wages to leverage the potential home–field advantage. One of these leverage points is certainly the scale economies associated with networks and local business knowledge. Conversely, location choices outside the region are hypothesized to be largely driven by market access, labor availability, and labor cost. Table 1 shows that single-unit firms on average have higher birth and death rates compared to multi-unit firms. Correlations between single-unit birth and death rates in 2000 (0.06) and 2004 (0.10) are also higher compared to multi-unit rates in 2000 (0.06) and 2004 (0.04).

Agglomeration (*A*) economies are measured in 2000 levels by the percentage of manufacturing establishments with less than 10 employees, manufacturing's share 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 average share of manufacturing employment is 15% with a minimum of zero and maximum of 64%. 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 entry/exit rates in a county. 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.

A county's market structure (*S*) is measured by per capita income and population. Per capita income and population proxy the wealth and size of a market, respectively. A county with more wealth and people increase the likelihood that it is a demand center for goods and services. Larger markets may be correlated with higher birth and death rates of manufacturing firms. All market structure data are from the Bureau of Economic Analysis (BEA).

Labor (*L*) availability and cost are measured by (respectively) county unemployment rates (Bureau of Labor Statistics, BLS) and average wage per job[1] (from the BEA). A high unemployment rate is hypothesized to attract manufacturing investment, whereas a high average 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 a bachelor's degree.

[1] The average wage per job measure was dropped from the empirical model due to a high level of collinearity between it and per capita income.

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 climate(*F*) is measured by local government tax revenue per capita and educational expenditures per capita (Census of Governments, 1997). Data for these measures were obtained from the 1997 Census of Governments. The Census is conducted every five years with 1997 being closest prior to 2000. The later year was chosen instead of the 2002 census to avoid simultaneity issues. Counties providing more public services may be able to overcome the negative effects of higher incidences of tax on firms and employees.

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 rural or 'non-core'. These variables will pick up any unmodeled difference between rural and urban areas. Noncore and metropolitan counties are hypothesized to be at a locational disadvantage due to remoteness and high competition for resources, respectively. Additionally, firm birth and death rates may be different in counties due to the unobserved factors of the state in which they reside, such as environmental regulations or ease of conducting business. State fixed effects are used to account for unobserved heterogeneity.

<< Insert Table 1>>

5. Empirical Analysis

The empirical analysis applies a regional adjustment model to explain firm entry and exit rates between 2000 to 2004 period while using 2000 as the base year.   The dependent variables are:

$$\Delta b_{i,2004} = (b_{i,2004} - b_{i,2000}) \tag{2a}$$

$$\Delta d_{i,2004} = (d_{i,2004} - d_{i,2000}), \tag{2b}$$

where *i* indexes county *i*, and *b* and *d* equal the births and deaths over the 2000 to 2001 and 2004 to 2005 periods divided by the stock of manufacturing firms in 2000 and 2004, respectively. The empirical model is:

$$\Delta b_{i,2004} = \alpha_0 + \alpha_1 d_{i,2000} + \alpha_2 b_{i,2000} + \boldsymbol{\alpha}_3' \boldsymbol{x}_{i,2000} + \varepsilon^b_{i,2004} \tag{3a}$$

$$\Delta d_{i,2004} = \beta_0 + \beta_1 b_{i,2000} + \beta_2 d_{i,2004} + \boldsymbol{\beta}_3' \boldsymbol{x}_{i,2000} + \varepsilon^d_{i,2004}, \tag{3b}$$

where $\boldsymbol{x}$ is a vector of location determinants. Seemingly Unrelated Regression is typically used to estimate the reduced form equations (3a) and (3b) when the regressors are different (Carruthers and Mulligan, 2007; Carruthers and Vias, 2005). Here, SUR is equivalent to estimating the equations separately with OLS because we hypothesize the same local determinants influence firm entry and exit. As a sensitivity check, firm birth and death rates are estimated comparing single and multi-unit firms in different specifications. Standard errors are adjusted to account for heteroskedasticity.

The base model estimates are in Table 2. The left column of the table corresponds with single unit birth and death rates. In the firm birth equation, the agglomeration measures significantly contributed to a positive difference in firm birth rates between 2000 and 2004 (with the exception of manufacturing's share of employment). The market structure measures of per capita income and population were negatively correlated with firm birth, which may seem surprising. Although only the per capita income coefficient was significant, the negative affect may be due to the downturn in the economy between 2000 and 2001. However, per capita income also is a proxy for wages. Since it is highly correlated with the average wage per job measure, only per capita income is retained. Higher labor costs are expected to be negatively correlated with the firm birth rate. The coefficient on unemployment rate has the opposite expected sign. However, the measure of skilled labor is positive and statistically significant. The fiscal measures hypothesized to impact firm birth performed poorly in this specification. The infrastructure measures both have negative signs, with only public road density being significant. This may indicate that too much infrastructure leads to congestion and firms deciding to locate elsewhere. Birth and death rates in 2000 have the expected signs in the birth equation. A one percent increase in *dr00* increases the difference in birth rates by 0.11%. A one percent increase in the *br00* decreases the difference in birth rates by almost a full percent, 0.98%. This reflects the catch-up effect described previously.

The single-unit firm death equation did not perform as well as the birth equation (Table 2). However, there is a symmetric relationship between previous period birth and death rates across equations. A higher death rate in 2000 significantly reduced the difference between firm entry and exit rates in 2004. The positive coefficient on *pelt10* suggests that counties with a high proportion of smaller firms as measured by employment can expect a higher death rate *ceteris paribus*. The results also show that rural counties experienced a greater difference in entry-exit rates compared to micropolitan counties.

<< Insert Table 2 >>

The right column of Table 2 displays the results of the same models, but only for multi-unit firms. Coefficients are comparatively smaller for the birth and death equations. This may be due to the fact that birth and death rates are lower for multi-unit firms on average (Table 1). Multi-unit firms do not appear to display the symmetric relationship between birth and death. One main difference of the multi-unit firms is their response to access to interstate infrastructure, with a positive coefficient reported in the birth equation and a negative coefficient in the death equation. Metropolitan counties have a positive coefficient in the multi-unit death equation, which may be due to increased competition found in these areas.

Table 3 reports estimation results from the base model including state fixed effects. The state fixed effects are not reported. Results are very similar between the single-unit birth and death equations. Symmetry between , but to a lesser extent than in the base model. A high percentage of small establishments in the base year is correlated with firm exit rate over the five year period. Compared to the base model, the results are similar for multi-unit firms, although the agglomeration and infrastructure measures are no longer significant. Noncore counties again have lower firm birth rates.

<< Insert Table 3 >>

The hypothesis that the marginal effects of the location determinants were similar across counties located in metropolitan, micropolitan, and noncore regions was tested using a spatial regime model (de Graaff et al., 2001). A regime model can account for heterogeneity by allowing coefficients to vary across space. Appreciating such differences may better inform policy-makers based upon their county type in a broad sense. Table 4 shows the results from a spatial regime model. Each of the variables from the base model are interacted with the dummy variables coding for rural and metropolitan counties. Micropolitan counties are the reference group. Symmetry between birth and death rates disappears. In the birth equation, skilled labor and public roads in rural counties (*rpedbs* and *rproad*) increase the birth rate from 2000 to 2004. This result is not found for metropolitan counties, which likely have higher levels of skilled labor and public road networks. Increasing the mileage of interstates in metropolitan counties reduces the birth rate, which may also be an indication of congestion. This is quite interesting while comparing results in the single-unit death equation. Expenditures on highways, a proxy for infrastructure maintenance, are negatively correlated with firm exit in metropolitan counties. However, highway expenditures in rural counties are correlated with increases in firm exits, which may indicate better connectivity to micro and metropolitan counties. Education expenditures, unemployment rates (a measure of labor availability), and local agglomeration of existing manufacturing employment are negatively correlated with death rates in rural counties.

<< Insert Table 4 >>

Multi-unit firms' birth rate is positively and significantly correlated with population in both rural and metropolitan counties, all else constant. Higher education expenditure in rural counties is associated with the birth rate of multi-unit firms, as does public road density. Somewhat unexpectedly, total establishment density in rural counties decreases the birth rate. Higher percentages of small and large firms in rural counties decrease the death rate of multi-unit firms. This may indicate that sunk costs play a larger role in rural areas. It may be harder and more costly to move manufacturing activities out of a rural county. This result is not evident in metropolitan counties. Interstates in rural counties decrease the death rate of multi-unit firms.

Table 5 reports estimation results of the spatial regime model with state fixed effects. As before, the state effects are not shown. Location determinants are less significant. Skilled labor in rural counties has a positive and significant effect on single-unit births. Coefficients of the base period birth and death rates across the birth and death equations are not symmetric. Both coefficients are near -1.0. Rural counties are once again shown to have a larger difference in the death rates between 2000 and 2004 compared to micropolitan counties. Higher unemployment rates, skilled labor and education expenditures decrease the difference in single-unit death rates.

<< Insert Table 5 >>

In this specification, multi-unit firms have higher birth rates in rural and metro counties with more population, and rural counties with higher public road densities. Firm birth rates are negatively correlated with rural and metro firm density, as well as available land in rural counties. Metropolitan counties have significantly lower firm exit rates compared to micropolitan counties. Multi-unit firm death rates are lower in rural counties with high percentages of small establishments and interstate highways. Symmetry is absent in this specification as a general result.

The results across the four specifications suggest that location factors do impact firm birth and death rates, but more so single-unit firms. Reponses to the location determinants vary across space as evidenced by the differences in coefficients for rural and metropolitan counties. The impact of infrastructure on birth and death rates is also a key difference between these county types, especially rural. This may be due to a lower stock of infrastructure compared to micropolitan and metropolitan counties. Skilled labor and education expenditures were significantly correlated with the birth rates of single and multi-unit firms in rural counties. Despite the use of the same regressors across all of the birth and death equations, cross-model correlation of the residuals was around 0.12 for single-unit firms and 0.03 for multi-unit firms. Model results will likely be improved if this correlation across the error terms can be exploited. Additionally, the stability of the system should be checked to determine if a long-run equilibrium between birth and death rates is achieved.

6. Conclusions

This research contributes to the empirical literature examining at short-run firm entry-exit dynamics using a regional adjustment model. Data on single- and multi-unit firms was used to determine birth and death rates of manufacturing firms at the county level for the lower 48 U.S. states. Single-unit firms had, on average, higher birth and death rates compared to multi-unit firms. This may reflect the fact that smaller firms make up a larger percentage of economic activity. Econometric results were robust across different empirical models, including state fixed effects and a spatial regime models allowing for regionally varying marginal effects. While symmetry between firm birth and death is established in earlier specifications, it is not in the spatial regime models. However, the regime models do show significant differences of the impacts of infrastructure in rural and metropolitan counties. Birth rates also respond well to education spending and a skilled work force in rural counties.

Future work should better exploit the remaining information in the cross-correlation of the residuals form the birth and death equations. It would also be useful to specify the structural equations in order to explicitly model the implied endogenous effects of birth on death and death on birth. Doing so would allow for better testing of Schumpeter’s theory of “creative destruction.” Lastly, it would be beneficial to determine whether or not the system is stable and if so what are the equilibrium manufacturing firm birth and death rates.

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Table 1. Empirical Measures

Variables	Label	Average	Stdev	Min	Max
INDEPENDENT (2000)					
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
Population density (population per square mile)	popdens	183.90	1160.97	0.10	45589.43
Per capita income ($)	pci	23080.09	5831.59	7480.00	85752.00
Population	pop	91036.68	295680.90	65.00	9545829.00
Average wage per job ($)	awage	24686.17	5592.08	13673.00	74381.00
Unemployment Rate (%)	uer	4.32	1.64	1.40	17.50
Bachelor's Degree (% of population 25 years +)	pedas	5.70	1.99	0.38	15.60
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
Highway per capita expenditures ($)	hwypc	177.48	250.04	0.00	7603.98
Tax revenue per capita ($)	taxrevpc	851.70	1471.71	49.63	68213.69
Govt. expenditure per capita ($)	govexpc	2479.54	4251.15	183.00	198510.00
Education spending per capita ($)	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
Rural county	rural	0.44	0.50	0.00	1.00
DEPENDENT					
Single unit firm birth rate (2000)	subr00	6.44	8.75	0.00	100.00
Single unit firm death rates (2000)	sudr00	6.68	7.66	0.00	100.00
Single unit firm birth rate (2004)	subr04	5.90	7.72	0.00	100.00
Single unit firm death rates (2004)	sudr04	6.45	8.21	0.00	100.00
Multi unit firm birth rate (2000)	mubr00	0.90	2.52	0.00	50.00
Multi unit firm death rates (2000)	mudr00	1.23	2.93	0.00	50.00
Multi unit firm birth rates (2004)	mubr04	0.86	2.68	0.00	66.67
Multi unit firm death rates (2004)	mudr04	1.06	3.18	0.00	100.00

N = 3,078

Table 2. Base Model

	Single-Unit Birth		Single-Unit Death		Multi-Unit Birth		Multi-Unit Death	
	Coefficient[1]	Std. Error[2]	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
dr00	0.1130**	0.0616	-0.9566***	0.0593	-0.0149***	0.0113	-1.0191***	0.0180
br00	-0.9787***	0.0432	0.0969	0.0601	-0.9808***	0.0252	0.0487	0.0360
pelt10	0.0609***	0.0151	0.0924***	0.0182	-0.0025	0.0028	-0.0084	0.0075
pemt100	0.0275***	0.0244	0.0499	0.0554	0.0109	0.0071	0.0001	0.0103
pci	-0.0001**	1.00E-04	-4.47E-05	7.27E-05	-1.24E-05	8.51E-06	-8.32E-06	1.66E-05
pop	-1.44E-07	3.25E-07	2.36E-07	3.20E-07	-2.21E-07**	1.05E-07	1.18E-07	9.22E-08
uer	-0.2418**	0.1317	0.0875	0.1648	-0.0005	0.0303	0.1191**	0.0518
pedbs	0.1731**	0.0785	0.0113	0.0879	-0.0182*	0.0110	-0.0116	0.0163
msemp	-0.0022	0.0208	-0.0499	0.0399	-0.0025	0.0057	0.0125*	0.0070
tfdens	0.0036***	0.0010	0.0014	0.0011	0.0003*	0.0002	-0.0001	0.0003
educpc	-1.74E-04	1.83E-04	1.79E-04	1.33E-04	2.40E-05	2.27E-05	-3.80E-06	3.98E-05
hwypc	0.0004	0.0012	-0.0012	0.0008	-0.0002	0.0001	-0.0001	0.0002
proad	-0.4059***	0.0786	-0.0788	0.0826	-0.0291	0.0190	0.0039	0.0392
interst	-0.0007	0.0068	-0.0010	0.0063	0.0044*	0.0024	-0.0038**	0.0021
avland	-0.0201***	0.0063	-0.0082	0.0067	-0.0038**	0.0017	0.0041	0.0033
metro	0.6279	0.3876	0.2494	0.3402	-0.0698	0.1224	0.3139*	0.1878
rural	0.5718	0.3750	0.8427**	0.4366	-0.2921	0.1226	0.0848	0.1355
constant	4.9647***	1.2377	1.7537	1.4962	1.6560***	0.3604	0.9228	0.6208
State Fixed Effects = no								
R^2	0.4789		0.3493		0.4992		0.3909	
F-Statistic	52.37		23.50		101.62		232.88	

[1] Significance levels ***,**,* correspond to 1%, 5%, and 10% .

[2] Standard errors are robust to heteroskedasticity.

Table 3. Base Model with State Fixed Effects

	Single-Unit Birth		Single-Unit Death		Multi-Unit Birth		Multi-Unit Death	
	Coefficient[1]	Std. Error[2]	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
dr00	0.1099*	0.0613[2]	-0.9533***	0.0587	-0.0141	0.0114	-1.0260***	0.0184
br00	-0.9849***	0.0430	0.0956	0.0597	-0.9858***	0.0251	0.0459	0.0371
pelt10	0.0601***	0.0151	0.0926***	0.0183	-0.0024***	0.0029	-0.0083***	0.0070
pemt100	0.0172	0.0264	0.0487	0.0569	0.0085	0.0075	-0.0010	0.0103
pci	-0.0001**	6.02E-05	-0.0001	7.85E-05	-8.03E-07	1.06E-06	-1.70E-06	1.85E-05
pop	1.96E-07	3.19E-07	1.04E-07	3.92E-07	-2.25E-07*	1.220E-07	2.40E-07*	1.34E-07
uer	-0.2327	0.1652	0.0350	0.2120	-0.0040	0.0354	0.1043*	0.0612
pedbs	0.1571*	0.0881	0.0265	0.0881	-0.0152	0.0144	-0.0183	0.0194
msemp	-0.0077	0.0222	-0.0318	0.0387	0.0001	0.0065	-0.0031	0.0124
tfdens	0.0034***	0.0011	0.0016	0.0012	0.0001	0.0002	-1.77E-05	0.0003
educpc	-0.0001	0.0002	0.0002*	0.0001	3.22E-05	2.39E-05	2.38E-05	3.54E-05
hwypc	-4.24E-05	0.0012	-0.0014	0.0008	-0.0002	0.0001	-0.0003	0.0002
proad	-0.3912***	0.0930	0.0121	0.0921	-0.0139	0.0203	-0.0092	0.0304
interst	0.0004	0.0066	-0.0055	0.0076	0.0030	0.0022	-0.0031	0.0022
avland	-0.0171*	0.0088	-0.0117	0.0101	-0.0022	0.0024	0.0084	0.0067
metro	0.4358	0.3779	0.3036	0.3548	-0.1126	0.1243	0.2438	0.1850
rural	0.4017	0.3721	0.7715*	0.4241	-0.2134*	0.1275	0.1026	0.1468
const	5.1030***	1.3857	1.8379	1.9906	1.2038***	0.3888	1.1930	0.8475
State Fixed Effects = yes								
R^2	0.4902		0.3583		0.5164		0.4003	
F-Statistic	21.82		8.87		43.25		80.95	

[1] Significance levels ***,**,* correspond to 1%, 5%, and 10% .

[2] Standard errors are robust to heteroskedasticity.

Table 4. Spatial Regime Model

	Single-Unit Birth		Single-Unit Death		Multi-Unit Birth		Multi-Unit Death	
	Coefficient[1]	Std. Error[2]	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
dr00	0.0680	0.0666[2]	-0.9402***	0.0899	-0.0150	0.0117	-1.0216***	0.0189
br00	-0.9891***	0.0687	0.0005	0.0765	-0.9777***	0.0252	0.0481	0.0366
pelt10	0.0452*	0.0236	0.1060***	0.0371	0.0069	0.0079	0.0025	0.0061
pemt100	0.0049	0.0404	-0.0455	0.0410	0.0080	0.0162	0.0251*	0.0142
pci	-4.44E-05	0.0001	-0.0002**	0.0001	-2.58E-05	2.61E-05	-3.81E-05	2.54E-05
pop	-1.10E-05	1.08E-05	-1.35E-06	9.36E-06	-8.28E-06*	4.83E-06	-9.81E-07	3.53E-06
uer	-0.3465	0.2373	0.7134*	0.4063	0.0309	0.0991	0.0450	0.0745
pedbs	0.0170	0.1018	0.3011***	0.1050	-0.0340	0.0338	0.0078	0.0263
msemp	-0.0204	0.0338	0.0626*	0.0337	0.0045	0.0099	-0.0031	0.0110
tfdens	-0.0593	0.2660	-0.1547	0.2869	0.1452	0.0903	0.1594*	0.0958
educpc	-0.0008	0.0008	0.0034***	0.0011	-0.0001	0.0002	-0.0002	0.0001
hwypc	-0.0016	0.0018	-0.0063***	0.0024	-0.0001	0.0010	0.0001	0.0005
proad	-0.7399*	0.4027	0.4370	0.5867	-0.2136*	0.1150	0.0459	0.0902
interst	0.0259	0.0159	-0.0076	0.0104	0.0118	0.0072	0.0032	0.0039
avland	-0.0165*	0.0099	-0.0027	0.0137	-0.0002	0.0039	0.0004	0.0031
metro	0.7789	5.0577	5.2170	4.1735	-0.3870	1.4525	-1.1702	1.2360
rural	-6.6256*	3.9492	8.3460*	4.7225	-0.7526	1.3231	1.1475	1.9500
rdr00	0.0675	0.1034	-0.0270	0.1170	0.0204*	0.0115	0.0012	0.0112
rbr00	0.0308	0.0870	0.0710	0.1002	0.0040	0.0058	0.0055	0.0138
rpelt10	0.0195	0.0284	-0.0149	0.0438	-0.0107	0.0085	-0.0179*	0.0102
rpemt100	0.0180	0.0521	0.1364	0.0935	-0.0054	0.0175	-0.0364*	0.0197
rpci	-3.69E-05	1.39E-04	0.0002	0.0002	2.79E-05	3.20E-05	1.07E-05	0.0001
rpop	7.08E-06	1.12E-05	9.03E-06	9.84E-06	1.04E-05**	4.98E-06	-5.23E-07	3.88E-06
ruer	0.1065	0.2932	-0.8029*	0.4738	-0.0880	0.1065	0.1045	0.1144
rpedbs	0.3572*	0.1907	-0.2582	0.2403	-0.0051	0.0394	-0.0637	0.0442
rmsemp	0.0183	0.0497	-0.1679**	0.0784	-0.0035	0.0125	0.0268*	0.0161
rtfdense	0.1900	0.3736	0.3610	0.3924	-0.3098**	0.1238	-0.0187	0.1976
reducpc	0.0001	0.0010	-0.0037***	0.0013	0.0005*	0.0002	0.0000	0.0004
rhwypc	0.0016	0.0022	0.0053***	0.0025	-0.0001	0.0010	-0.0002	0.0005
rproad	1.4378*	0.7747	-0.5338	1.0300	0.4813***	0.1846	-0.3655	0.3473
rinterst	-0.0303	0.0234	0.0163	0.0223	-0.0106	0.0084	-0.0128**	0.0056
ravland	-0.0195	0.0166	-0.0127	0.0194	-0.0118**	0.0051	0.0147	0.0102
mdr00	-0.0268	0.1337	-0.0053	0.1357	0.0154	0.0296	-0.0791	0.0603
mbr00	-0.0775	0.0968	0.2780	0.2142	0.0143	0.0126	-0.0456	0.0442
mpelt10	-0.0139	0.0736	-0.0290	0.0426	-0.0207*	0.0123	0.0331	0.0367
mpemt100	-0.0034	0.0825	0.0832	0.0570	0.0252	0.0282	-0.0088	0.0203
mpci	-0.0001	0.0001	0.0002**	0.0001	1.43E-05	2.76E-05	2.33E-05	4.15E-05
mpop	1.15E-05	1.08E-05	1.38E-05	9.36E-06	8.11E-06*	4.83E-06	1.11E-06	3.53E-06
muer	0.3263	0.4149	-0.6523	0.4294	0.0145	0.1109	0.0518	0.1063
mpedbs	0.1753	0.1689	-0.4202***	0.1176	0.0410	0.0361	-0.0001	0.0414
mmsemp	-0.0106	0.0442	-0.0682*	0.0399	-0.0236	0.0174	0.0172	0.0195
mtfdense	0.0636	0.2660	0.1549	0.2869	-0.1451	0.0903	-0.1590*	0.0958
meducpc	0.0005	0.0009	-0.0034***	0.0011	0.0001	0.0002	0.0003	0.0002
mhwypc	0.0025	0.0042	0.0083**	0.0036	-0.0003	0.0012	-0.0009	0.0017
mproad	0.2913	0.4168	-0.4255	0.5919	0.1885	0.1168	-0.0919	0.1010
minterst	-0.0360**	0.0181	0.0077	0.0110	-0.0095	0.0078	-0.0062	0.0046
mavland	-0.0064	0.0140	-0.0055	0.0163	0.0018	0.0046	-0.0033	0.0067
const	8.6175**	3.3230	-4.4092	3.6383	1.8109	1.1676	1.1013	0.8255
State Fixed Effects = no								
R^2	0.4850		0.3586		0.5062		0.4005	
F-Statistic	36.76		17.56		65.72		42.60	

[1] Significance levels ***,**,* correspond to 1%, 5%, and 10% .

[2] Standard errors are robust to heteroskedasticity.

Table 5. Spatial Regime Model with State Fixed Effects

	Single-Unit Birth		Single-Unit Death		Multi-Unit Birth		Multi-Unit Death	
	Coefficient[1]	Std. Error[2]	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
dr00	0.0480	0.0659[2]	-0.9475***	0.0719	-0.0165	0.0236	-0.9995***	0.0428
br00	-1.0035***	0.0685	-0.0071	0.0700	-1.0571***	0.0417	0.0254	0.0619
pelt10	0.0442*	0.0233	0.1063***	0.0322	0.0063	0.0079	0.0011	0.0064
pemt100	-0.0208	0.0419	-0.0480	0.0629	0.0081	0.0172	0.0210	0.0148
pci	-1.78E-06	0.0001	-0.0002*	0.0001	0.0000	2.61E-05	0.0000	3.54E-05
pop	-9.16E-07	1.09E-05	-7.88E-06	1.99E-05	-1.21E-05**	5.13E-06	0.0000	4.20E-06
uer	-0.3796	0.2411	0.7535**	0.3236	0.0669	0.1004	0.0341	0.0841
pedbs	0.0121	0.1016	0.3508**	0.1407	-0.0273	0.0364	-0.0003	0.0318
msemp	-0.0299	0.0347	0.0850	0.0587	0.0106	0.0102	-0.0144	0.0134
tfdens	-0.3104	0.2750	-0.1928	0.5682	0.1990**	0.0885	0.0893	0.1071
educpc	-0.0004	0.0009	0.0041***	0.0011	-0.0001	0.0002	-0.0002	0.0002
hwypc	-0.0035*	0.0019	-0.0068**	0.0034	-0.0003	0.0010	0.0003	0.0006
proad	-0.6118	0.4011	0.4488	0.6585	-0.1416	0.0911	0.1123	0.0973
interst	0.0253*	0.0143	-0.0111	0.0195	0.0107	0.0074	0.0014	0.0048
avland	-0.0167	0.0112	-0.0032	0.0182	0.0009	0.0043	0.0045	0.0048
metro	-0.6132	4.8764	7.0630	5.2330	0.1840	1.4336	-2.4195*	1.3395
rural	-5.8168	3.8746	9.286*	4.9290	-0.0939	1.3340	1.2502	1.9722
rdr00	0.0893	0.1037	-0.0150	0.0769	0.0056	0.0266	-0.0270	0.0493
rbr00	0.0403	0.0881	0.0792	0.0741	0.0885*	0.0521	0.0228	0.0782
rpelt10	0.0191	0.0274	-0.0148	0.0342	-0.0082	0.0084	-0.0160*	0.0094
rpemt100	0.0412	0.0522	0.1362**	0.0695	-0.0073	0.0183	-0.0296	0.0185
rpci	-0.0001	0.0001	0.0002	0.0002	0.0000	3.19E-05	0.0000	0.0001
rpop	-2.28E-06	1.13E-05	5.72E-06	2.04E-05	1.36E-05***	5.19E-06	0.0000	4.29E-06
ruer	0.0493	0.2850	-0.9439***	0.3612	-0.1156	0.1055	0.0862	0.1245
rpedbs	0.3614**	0.1809	-0.2647	0.1715	-0.0231	0.0407	-0.0655	0.0461
rmsemp	0.0173	0.0488	-0.17**	0.0682	-0.0080	0.0124	0.0209	0.0176
rtfdense	0.3815	0.3728	0.2493	0.6316	-0.3374**	0.1196	0.0274	0.2080
reducpc	-0.0001	0.0010	-0.0042***	0.0012	0.0003	0.0003	0.0001	0.0004
rhwypc	0.0030	0.0022	0.00591*	0.0035	0.0001	0.0010	-0.0005	0.0006
rproad	1.2098	0.8060	-0.4633	1.0320	0.37859**	0.1808	-0.4175	0.3580
rinterst	-0.0276	0.0219	0.0145	0.0257	-0.0105	0.0082	-0.0121**	0.0059
ravland	-0.0163	0.0153	-0.0151	0.0220	-0.012658**	0.0051	0.0153	0.0104
mdr00	-0.0239	0.1299	-0.0083	0.0978	-0.0059	0.0482	-0.0918	0.0564
mbr00	-0.0720	0.0937	0.2756***	0.0907	0.0586	0.0567	0.0140	0.0922
mpelt10	-0.0077	0.0711	-0.0211	0.0438	-0.0181	0.0118	0.0231	0.0254
mpemt100	0.0023	0.0819	0.0791	0.0833	0.0196	0.0296	0.0026	0.0199
mpci	-0.0001	0.0001	0.0002	0.0002	0.0000	2.76E-05	0.0000	4.50E-05
mpop	1.48E-06	1.09E-05	8.02E-06	1.99E-05	1.20e-06**	5.12E-06	0.0000	4.18E-06
muer	0.5463	0.4296	-0.8336**	0.4187	-0.0371	0.1104	0.1277	0.1187
mpedbs	0.1491	0.1644	-0.4259**	0.1674	0.0265	0.0377	-0.0014	0.0410
mmsemp	-0.0017	0.0444	-0.0767	0.0735	-0.0266	0.0173	0.0196	0.0188
mtfdense	0.3143	0.2753	0.1938	0.5683	-0.1991**	0.0885	-0.0896	0.1072
meducpc	0.0001	0.0009	-0.0041***	0.0011	0.0001	0.0002	0.0002	0.0002
mhwypc	0.0029	0.0040	0.0091*	0.0052	-0.0014	0.0012	-0.0007	0.0021
mproad	0.1675	0.4163	-0.3195	0.6828	0.1446	0.0930	-0.1384	0.1100
minterst	-0.0292*	0.0162	0.0065	0.0232	-0.0108	0.0077	-0.0045	0.0050
mavland	-0.0005	0.0139	-0.0094	0.0225	0.0048	0.0045	-0.0022	0.0067
const	8.1123*	3.9032	-13.4900	11.2600	0.8280	1.2256	0.1652	1.2096
State Fixed Effects = yes								
R^2	0.4818		0.3684		0.5236		0.4085	
F-Statistic	31.12		18.31		34.50		21.68	

[1] Significance levels ***,**,* correspond to 1%, 5%, and 10% .

[2] Standard errors are robust to heteroskedasticity.