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# "Exploring the Firm Population Dynamics in the Turkish Manufacturing Industry: A Time Series Application for the 1950-2000 Period"

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## ABSTRACT

This paper, examines the 1950-2000 period population dynamics of Turkish manufacturing firms using annual data on the aggregate industry. We first check the time series properties of the data and then consider four different models. The *density dependence model* seems to be the most appropriate one for the data. The selected model is then extended. Density seems to have a negative impact on the population growth rate. Furthermore, the population growth rate appears to diminish as the growth rate of average firm size rises, confirming some cross-sectional results based on more specifically defined industries. On the other hand, population growth rate does not depend on growth rates of energy intensity, average payments to employees, and real GDP per capita.

Keywords: industry population dynamics, time series, manufacturing

JEL codes: L1, L6

## 1. INTRODUCTION AND LITERATURE REVIEW

Adaptation and selection are two channels through which markets respond to exogenous factors (Geroski and Mazzucato, 2001). The population dynamics of the firms in an industry therefore may convey important information regarding the evolution of that industry. Geroski and Mazzucato (2001) (GM hereafter) point out that industry population dynamics may have an impact on the competitive conditions in a single market. They also argue that industry population dynamics usually follow interesting patterns which might worth examining.

There is a considerable amount of studies in the literature that examine the entry and exit dynamics in both developed and developing country industries. Geroski (1995) surveys the earlier literature on entry and Caves (1998) on turnover and mobility. Most of the earlier works seem to employ either a cross sectional or a pooled cross section, time series approach.

More recently, Amel and Liang (1997) estimate entry and exit equations for local banking markets in the U.S. over a nine year period. Ilmakunnas and Topi (1999) study the effects of both microeconomic and macroeconomic factors on entry and exit dynamics in a cross section of Finnish manufacturing industries that cover five years of panel data. Employing eight years of data on Japanese manufacturing industries, Doi (1999) studies firm exits. For three Greek manufacturing industries, Fotopoulos and Spence (1999) use ten years of data to study the net entry behavior. Lay (2001) utilizes eleven years of data to study the relationship between entry and exit in the manufacturing sector of Taiwan. Roberts and Thompson (2003) study Polish 3-digit industries over a five year period and Disney et al. (2003) examine the determinants of entry and exit within a five year period in the U.K. manufacturing industry. More recently, Martin-Marcos and Jaumandreu (2004) relate productivity differences of firms to their entry and exit decisions by using GMM estimation for eleven years of panel data on Spanish manufacturing industry.

Intuitively, “population dynamics” and “entry exit dynamics” imply a longitudinal process in a single industry; however, cross sectional and pooled approaches dominate the literature. Geroski (2001) indicates the need for long run analysis of the population number of firms in industries. He argues that the literature is dominated by cross-section examination of the determinants of entry and exit and time series models may yield promising results in terms of theoretical and empirical improvements in the literature. Additionally, Mathis and Koscianski (1996) point out the fact that focusing on an individual industry time series will eliminate the problems faced by cross-section and pooled time series, cross-section models.

Although, cross sectional studies uncovered important stylized facts on market dynamics and are still being used frequently, the potential of longitudinal studies is not completely overlooked. Klepper and Graddy (1990), Jovanovich and MacDonald (1994), Mathis and Koscianski (1996), and GM (and all others in the Special Issue of the *International Journal of Industrial Organization* (2001) on market evolution) are studies that utilize longitudinal data. However, they are not directly comparable since they are utilizing different techniques along with different types of data. In this paper, we follow the foot steps of GM. GM identify four complementary models that relate net entry to the number of firms, sales and time trends. They refer to these models as *the market size model*, *the negative feedback model of entry and exit*, *the contagion model of entry and* *exit*, and *the density dependence model*. They also show that the models are closely related and three of the models may be reduced to the third model (contagion model of entry and exit), but they are still not completely nested. Their empirical results utilizing 93 years of data on the domestic car producers in the U.S. imply that the contagion model is the most robust one, although the density dependence model also seems to fit reasonably well.

This paper builds on the models discussed in GM. Fifty years of data (1950-2000) on Turkish manufacturing industry is used to examine the firm population dynamics and to select the most appropriate model out of the four in GM. The main contributions of this paper are two folds. Firstly, we focus on the aggregate manufacturing industry and employ a time series approach to an issue that has been analyzed by predominantly cross sectional studies over more specifically defined industries. Geroski (1995) notes that entry differences between industries do not persist and variation is due to within industry variation rather than between industry variation. Hence, our results based on aggregate industry data appear to be valid. Furthermore, annual data may be more appropriate in capturing the population dynamics. Secondly, to the extent of our knowledge, no one has examined the dynamics of firm populations (either cross sectional or time series) in any Turkish industry before. Kaya and Ucdogruk (2002) utilize dynamic panel data analysis to investigate the determinants of entry and exit in 4-digit ISIC level manufacturing industries in Turkey for the period 1981-1997. In that respect, both the methodology and the data employed are relatively new to the literature. Furthermore, we consider four more explanatory variables to extend the selected density dependence model and find evidence that the population growth rate is significantly hampered by the growth of the average firm size and does not seem to respond significantly to business cycles, changes in average labor cost, and in energy intensity. Hence, our results from the aggregate Turkish manufacturing industry seem to confirm studies that find similar results in more specific markets.

Section 2 briefly introduces the four models in GM and the data. Section 3 discusses the replication of the statistical results in GM using Turkish manufacturing data. Section 4 discusses the extensions to the selected model in section 3. Section 5 provides estimation results and section 6 concludes.

## 2. MODELS AND DATA

The non-nested market size, negative feedback, contagion, and the density dependence models are given in equations 1-4 respectively:

$$\Delta N_t = \varphi_0 + \varphi_1 N_{t-1} + \varphi_2 S_{t-1} + \varphi_3 \Delta N_{t-1} + \varphi_4 \Delta St_{-1} + \varepsilon_t \quad (1)$$

$$\Delta N_t = \theta_0 + \theta_1 N_{t-1} + \varepsilon_t \quad (2)$$

$$\Delta N_t = \alpha_0 + \alpha_1 N_{t-1} + \alpha_2 \Delta N_{t-1} + \varepsilon_t \quad (3)$$

$$\Delta N_t = \beta_0 + \beta_1 N_{t-1} + \beta_2 N_{t-1}^2 + \varepsilon_t \quad (4)$$

where t is the time subscript, Δ is the first difference operator, N is the number of firms, and S is the value of sales (represents the market size). Other variables considered by GM are the time trend and quadratic time trend. However, they argue that these four models may be the baseline for more complicated models in the future.[1]

GM also argue that the dynamics of industry populations will most likely be modeled using the contagion version along with other variables. Since it is not the main focus of their paper, they do not consider the effects of other firm level, industry level,

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[1] The derivation of the models are not included here to conserve space, we refer the reader to GM.

and macroeconomic variables; hence, their application in US car manufacturing industry may be suffering from omitted variables bias. They report rather low $R^2$ values in their application for the US car industry, except may be for the contagion model.

Entry and exit dynamics is likely to have long run repercussions on the market; therefore this study employs annual data, which may capture long run population dynamics ignoring short run distortions.

Since sales data is not available we use the value added data instead to reflect the size of the market in the simple form models in equations1-4. After selecting the appropriate model, we include average payments per employee to reflect the labor cost changes, electricity consumption to real value added ratio in manufacturing to represent energy intensity (called mechanization variable and used as a proxy for capital intensity, Fotopoulos and Spence, 1999), average number of employees to denote the average firm size, and GDP per capita to control for business cycles. Note that the data are available annually for the period 1950-2000 and are sourced from the Statistical Indicators publication of the State Institute of Statistics in Turkey, except for real GDP per capita, which is from the Penn World Tables. Note that the growth rates of average employment, real GDP per capita, average payments per employee, and energy intensity are computed from the data obtained and these growth rates are employed in the regressions. Next section presents and discusses the statistical results and compares the four models.

## 3. STATISTICAL RESULTS AND DISCUSSION

We first estimate the models as they appear in GM (except for the cubic trend) for the Turkish manufacturing industry. The statistical results from the simplest form models are summarized in Table 1.

(Table 1 about here)

The regressions (iii), (vi), (vii), and (viii) in Table 1 are the only ones with an overall significance. Regression (vi), which is based on the density dependence model, seems to be the best fit for our data. As GM state "*$N_{t-1}^2$ term is the distinctive feature of the density dependence model*" and is significant in (vi). Hence, the population growth rate of firms in the Turkish manufacturing sector depends on population density. Note that regression (v), which is the density dependence model without time trends is insignificant. Whereas, introducing trend terms as in (vi) seem to have a considerable contribution.

Although the linear, quadratic, and cubic trend terms have insignificant coefficients, joint redundancy of the terms is rejected at 1% by both the F (5.291072) and the log likelihood (15.40198) tests. However, the redundancy of the cubic trend alone cannot be rejected. GM note that the density dependence model, frequently used by organizational ecologists, is an S-shaped approach[2] to modelling population growth rate.

Restricting the coefficient of the cubic trend term to zero appears to improve the model. The restricted model has a lower p-value than the unrestricted model. Adjusted $R^2$ does not seem drop significantly (0.205734); hence, the explanatory power cannot be attributed to low sample size relative to the number of regressors. Probably, the most important feature of the restricted model is that the quadratic trend term is significant and the effect of $N_{t-1}^2$ seems to be slightly magnified (-6.539335)[3].

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[2] See Geroski (2001) for a discussion of the similarities and differences between industrial economics and organizational ecology approaches and Barron (2001) for a comment on Geroski (2001).

[3] Q statistics up to 24 are all insignificant and Bresuch-Godfrey test fails to reject no serial correlation upto 9 lags. Although, Ramsey RESET(1), and Chow breakpoint at 1962 fail to reject no instability, and CUSUM and CUSUMQ do not show any violation, the Chow forecast test rejects no instability at 1% for

The density dependence model with a quadratic trend is the most suitable one for the Turkish manufacturing industry (as opposed to regression viii for the US car producer population in GM). GM suggest that the models that they provide will be rooted in the more complicated models in the future. Considering other micro or macro variables is out of the scope of their work. In the previous section, we determine that the density dependence model is the most appropriate one for the Turkish manufacturing industry. Whether the explanatory power of the simplest form density dependence model may be improved or not is explored in the next section.

## 4. EXTENDING THE DENSITY DEPENDENCE MODEL

In this section, a limited number of variables (four) are considered in the extension of the selected model. These are the growth rates of real GDP per capita, average employment, average real payments made to employees, and electricity consumption per real value added. Figure 2 shows the time series patterns of these growth rates.

(Figure 2 about here)

Most notable aspects of these graphs may be the spikes observed in 1962 for the growth rates of average employment and electricity consumption per output. These spikes combined with the downturn in the number of firms in 1962 may indicate a shakeout in the industry. A crude visual analysis also implies that all series are likely to be stationary (nor one would usually suspect nonstationarity in growth rate series).

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1961. The 1962 was chosen as a result of the obvious downturn in Figure 1. Note that although Şenses and Taymaz (2003, p.452) (in Turkish) indicate 1960 and 1970 as the beginnings of structural changes in the Turkish manufacturing industry, both Chow forecast and breakpoint tests fail to reject the null for 1970 at 1% and 5% respectively. (all diagnostic results are available upon request)

Note, however, that if the series in concern are not stationary then the OLS yields spurious results. Hence, we employed Augmented Dickey-Fuller (1979) (ADF), Phillips-Perron (1988) (PP), Kwiatkowski, Phillips, Schmidt, and Shin (1992) (KPSS), Elliot, Rothenberg, and Stock's (1996) GLS-detrended Dickey-Fuller (DF-GLS), and Ng and Perron (NP) (2001)[4] unit root tests to examine the stationarity properties of the variables. There is no evidence in favor of a unit root in any of the growth rate series (results available upon request)[5].

The intuition behind economic growth is clear. Including the real GDP per capita growth in the regression is an attempt to control for the business cycles. Economic growth stimulates new entry (pull hypothesis). Note however that as the economy contracts unemployment rate rises (unemployment rate is commonly used as a proxy for entrepreneurial supply). The microeconomic implication is that the opportunity cost of entry declines. Therefore, a sharp decline in (or a negative) economic growth rate may also have positive affects on the number of firms in an industry (push hypothesis) (Ilmakunnas and Topi, 1999). The expected sign of economic growth in the regression is positive, since it is assumed that the pull effect dominates the push effect through time.

The lack of capital related data may be partially overcome by the inclusion of electricity consumption per output (Fotopoulos and Spence, 1999). In this model, we employ the growth rate of electricity consumption per real value added instead of changes in capital intensity. Beaudreau (2005) points out that the role of energy consumption in production is marginalized in the growth literature; which deviates from the engineering

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[4] See Maddala and Kim (1998) for an excellent treatment of ADF, PP, KPSS, and DF-GLS; and Ng and Perron (2001) for NP.

[5] For the unit root tests that are sensitive to lag lengths, the results are checked with three different lag selection criteria: Akaike information criterion (AIC), modified AIC, and general to specific t-test methodology.

convention of production. He argues that the relationship between energy and production should be accounted for by the economists. Indeed, Sari and Soytas (2004) results suggest that energy consumption is more important in explaining the forecast variance of output than labor and it is almost as explanatory as capital in Turkey. Changes in energy intensity is expected to have a negative effect on the population growth rate by discouraging entry and inducing exit, since as growth rate of energy intensity rises, the opportunity cost of staying in that industry also rises.

Percentage changes in average employment represent changes in the average firm size. Intuitively, what one expects to observe is a decline in the entry and exit rates (hence a decline in population growth rate) as the growth rate of typical size rises. As the growth rate of average firm size exceeds the growth rate of output, number of firms in the industry declines, a phenomenon referred to as “shakeout” in the literature (see Klepper and Graddy (1990), Jovanovich and Macdonald (1994), Horwath et al (2001), and Roberts and Thompson (2003) for example). A brief review of the growth rate of average employment in Figure 1 suggests that shakeout occurs in 1962[6]. Therefore, the expected sign of the coefficient of the average firm size growth rate is negative.

Growth rate of real average payments to employees represent annual growth of average wage expenses in the industry. Lay (2001) suggests adding the growth rate of average wage to account for labor cost effects for Taiwan’s manufacturing sector due to the comparative advantage the country has in labor cost. The inclusion of the variable also allows one to capture the disadvantages due to small firm sizes. Although energy

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[6] The reasons for the 1962 shakeout in Turkish manufacturing industry are out of the scope of this paper. The military coup in 1960 may have had an impact; however, no structural breaks are detected by the Chow breakpoint and forecast tests for 1960. We kindly refer the interested reader to Şenses and Taymaz (2003) (in Turkish) for a review of the Turkish industrialization process.

consumption appears to be slightly more important than labor in Turkey (Sari and Soytas, 2004), similar arguments in Lay (2001) may hold for the Turkish manufacturing industry. The expected sign of the average wage growth rate is negative in the density dependence model, since an increase in the labor cost growth rate may deter entry and induce exit.

## 5. ESTIMATION RESULTS

Equation 5 describes the full regression model when all of the variables in concern are included:

$$\Delta N_t = \beta_0 + \beta_1 N_{t-1} + \beta_2 N_{t-1}^2 + \beta_3 T + \beta_4 T^2 + \beta_5 RGDP_t + \beta_6 RPAY_t + \beta_7 EMP_t + \beta_8 ELEC_t + \varepsilon_t \qquad (5)$$

where N is the number of firms, T is trend, RGDP, RPAY, EMP, and ELEC represent growth rates of real GDP per capita, average real payments per employee, and average electricity consumption per real value added in manufacturing respectively, subscript t denotes time, and ε is the error term.

Table 2 illustrates the full density dependence regression results and the results of the regression model that is selected based on best subsets approach.

(Table 2 about here)

The full model is significant based on the overall F test (at 1%) and has a high explanatory power in terms of the adjusted coefficient of multiple determination (74.4%). Although the signs of the extending variables are as expected, except for average employment all coefficients appear to be insignificant. The population dynamics does not appear to be significantly affected by changes in average labor cost and energy intensity, and does not seem to follow the business cycles.

Since none of the variance inflation factors is above 5, collinearity does not appear to be a problem. Running the best subsets regression results in a density dependence model that only includes the growth rate of average employment based on both adjusted $R^2$ and the $C_p$ statistic (all unreported statistical results are available upon request). The slight improvement in the adjusted $R^2$ is obvious (75.4%), and the overall F test statistic is higher than the one in the full model. Note also that the high explanatory power of the regression cannot be attributed to the overly small sample size relative to the variables included in the regression equation (only a slight downward adjustment from $R^2$)[7]. Low explanatory power observed in the literature even for panel studies (Geroski, 1995) does not appear to be a problem in this study.

The selected regression model also features significant coefficients of all variables, except for T. A significant $N_{t-1}^2$ term indicates nonlinear density dependence; however, its affect appears to be marginal and negative. The number of firms in the previous period ($N_{t-1}$) seems to have a significant positive impact on the population growth rate; whereas, the coefficient on $N_{t-1}^2$ is negative but marginal for small population sizes. The firm number growth rate appears to follow a positive quadratic trend. Average firm size seems to be an extremely important factor driving the population dynamics in a significantly negative fashion. If one can assume that the growth rate of average firm size closely follows that of minimum efficient scale, this result should not be surprising. Based on the estimation results, the growth rate of population size in the Turkish manufacturing industry depends on a nonlinear density, quadratic trend, and average firm size.

## 6. CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

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[7] The diagnostic tests conducted on the residuals do not appear to indicate severe violations of the common assumptions such as normality and parameter stability. (results available upon request)

In this study we examine the dynamics of firm population in the Turkish manufacturing sector using longitudinal data and a time series perspective. Despite data limitations and quality concerns, the density dependence model in GM appears to be explaining the data reasonably well. Indeed we observe a relatively higher explanatory power than many studies in the literature. One interesting finding may be that business cycles do not play a role in determining the changes in firm numbers in the industry. The number of firms is negatively influenced by average number of employees which seems to be consistent with the literature on entry and exit; however, it does not appear to depend on average payments to employees. Energy intensity is another factor with no influence on population size dynamics.

One major shortcoming in this application is probably the lack of firm level data. Furthermore, the length of the series we employ is not too long (50 observations as opposed to 93 in GM) and additions of new variables (their differences and their lags) in the equations may rapidly deplete the degrees of freedom. Therefore, we have to keep the models as simple as possible. Not only that, but fifty years may not be enough to reflect the entire life cycle of a market. Another problem may be that the data is an aggregate of all the manufacturing industries in Turkey. More specifically classified industries may have different structural changes and population dynamics that may offset each other in the aggregated manufacturing industry data. Finally, the quality of the data may also be questioned; however, it is the only data available. Even in the presence of these limitations and problems, statistical results appear to be robust.

In essence, to the extent that longitudinal data is available, a time series investigation of the dynamics of firm population appears to be simple and promising, and may complement the cross sectional analysis. However, different manufacturing industries are likely to follow different models of population dynamics. Hence, an interesting and natural extension of this paper may be to use a time series approach in more specifically defined markets. Furthermore, firm level variables (for example profitability) are absent in the current application due to unavailability of data. The future research with a time series appeal may benefit from inclusion of firm level variables as well as extending the explored industry and macro level variables.

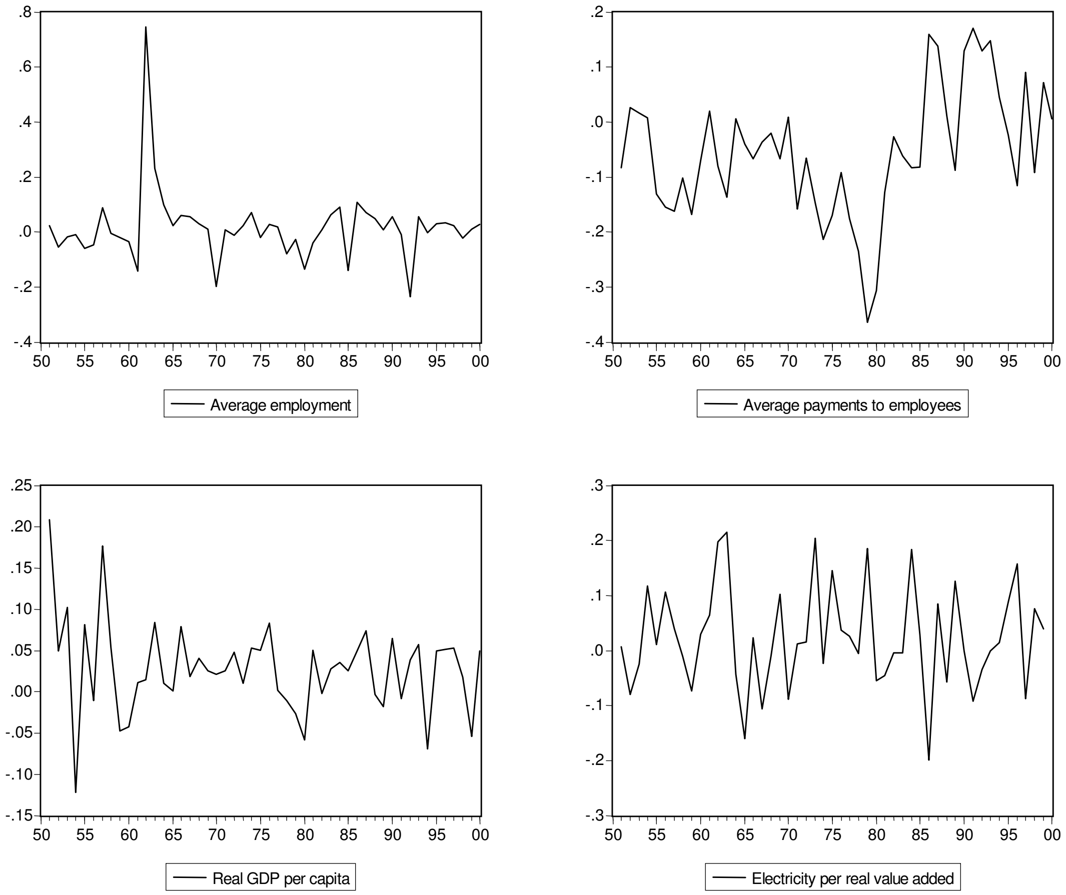

Figure 1. The growth rates of the exogenous variables in the density dependence model

Table1. Statistical Results Based on Simple Forms of the 4 models in GM

| | (i) | (ii) | (iii) | (iv) | (v) | (vi) | (vii) | (viii) |
|---|---|---|---|---|---|---|---|---|
| C | 2315.769 | 434.4541 | 1722.955 | 2116.413 | -431.4685 | -13.19901 | -561.4750 | -637.2684 |
| | (1057.90) | (190.668) | (810.205) | (950.351) | (770.649) | (1038.66) | (647.478) | (711.004) |
| $N_{t-1}$ | -0.375775 $^{c}$ | -0.039117 | -0.326702 $^{c}$ | -0.350739 $^{b}$ | 0.257267 | 0.411873 | 0.343670 | 0.369786 |
| | (0.18619) | (0.03092) | (0.16588) | (0.17325) | (0.28133) | (0.35647) | (0.22906) | (0.24752) |
| $N_{t-1}^{2}$ | - | - | - | - | -0.000021 | -0.000060 $^{b}$ | -0.000052 $^{a}$ | -0.000057 $^{a}$ |
| | | | | | (0.000019) | (0.000024) | (0.000019) | (0.000020) |
| $\Delta N_{t-1}$ | 0.017649 | - | - | 0.003424 | - | - | - | 0.097529 |
| | (0.16045) | | | (0.16039) | | | | (0.14413) |
| $\Delta VA_{t-1}$ | 0.007856 | - | - | - | - | - | - | - |
| | (0.01610) | | | | | | | |
| $VA_{t-1}$ | -0.012942 | - | - | - | - | - | - | - |
| | (0.01221) | | | | | | | |
| T | -155.1249 | - | -105.9795 | -151.3570 | - | -130.0870 | - | - |
| | (110.192) | | (87.5240) | (104.439) | | (81.7020) | | |
| $T^{2}$ | 10.07570 | - | 7.146670 | 9.063160 | - | 6.987854 | - | - |
| | (6.50855) | | (5.09934) | (5.79797) | | (4.85175) | | |
| $T^{3}$ | -0.098753 | - | -0.085415 | -0.106981 | - | -0.063125 | - | - |
| | (0.06981) | | (0.06244) | (0.07019) | | (0.06006) | | |
| T*(T-1) | - | - | - | - | - | - | 1.475411 $^{b}$ | 1.612108 $^{b}$ |
| | | | | | | | (0.65060) | (0.66311) |
| F-stat | 1.656449 | 0.358878 | 2.612003 $^{b}$ | 2.236520 $^{c}$ | 1.180132 | 3.190833 $^{a}$ | 5.226779 $^{a}$ | 3.915627 $^{c}$ |
| $R^{2}$ | 0.220460 | 0.019343 | 0.188429 | 0.206387 | 0.047817 | 0.300254 | 0.254219 | 0.262518 |
| Adjusted $R^{2}$ | 0.087368 | -0.001088 | 0.116289 | 0.114107 | 0.007299 | 0.220737 | 0.205582 | 0.195475 |

$\Delta N_t$ is the dependent variable, Δ denotes first difference, N is the number of firms, VA is real value added, T is trend. Subscript t denotes time, whereas superscripts a, b, and c represent significance at 1, 5, and 10% respectively. Standard errors are in parentheses and are White heteroscedastic consistent. F-stat is the overall F significance test for the model.

Table 2. Extending the density dependence model

| | Full model | Selected Model |
|---|---|---|
| C | -658.5196<br>(614.4498) | -595.9161<br>(436.4261) |
| $N_{t-1}$ | 0.428544<br>(0.291097) | 0.428427 $^{b}$<br>(0.195526) |
| $N_{t-1}^{2}$ | -0.000041<br>(0.000026) | -0.000042 $^{b}$<br>(0.000018) |
| T | -28.61530<br>(21.27762) | -26.49702<br>(17.17776) |
| $T^2$ | 1.090025<br>(0.718199) | 1.016905 $^{c}$<br>(0.599203) |
| RGDP | 1093.598<br>(918.8689) | - |
| RPAY | -359.9994<br>(951.9618) | - |
| EMP | -4816.013 $^{a}$<br>(812.9082) | -4848.360 $^{a}$<br>(635.8508) |
| ELEC | -325.5563<br>(583.0007) | - |
| F-stat | 18.40893 $^{a}$ | 31.05685 $^{a}$ |
| $R^2$ | 0.786406 | 0.779210 |
| Adjusted $R^2$ | 0.743688 | 0.754120 |

C is constant, N is number of firms, T is trend, RGDP, RPAY, EMP, and ELEC represent growth rates of real GDP per capita, average real payments per employee, and average electricity consumption per real value added respectively. Subscript t denotes time, whereas superscripts a, b, and c represent significance at 1, 5, and 10% respectively. Standard errors are in parentheses and are White heteroscedastic consistent. F-stat is the overall F significance test for the model. Diagnostic tests do not reveal serious violations of common assumptions for any of the two models.

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