Passive Firm Learning and Employment Projection Error

Todd M. Gabe
David S. Kraybill

ABSTRACT. This paper analyzes establishment error in estimating employment targets in business startups and expansions. Passive firm learning models provide a testable hypothesis that, other things being equal, old establishments more accurately predict future employment targets than young businesses. Empirical evidence from 442 Ohio establishments implies that an increase of ten years in establishment age is associated with a decrease in employment projection error rate of between 11 and 13 percentage points.

1. Introduction

Business establishments often promise the creation of a substantial number of jobs in startup and expansion projects. In many cases, an establishment reports plans for new jobs several months or even years before they are created due to lags between when projects are launched and when they are operational. Given the stochastic processes that drive market conditions and costs while an establishment is building a new plant or expanding its facility, the environment faced by an establishment when a project is operational may differ from its expectations at the start of a project. Thus, establishments undertaking startup and expansion projects may meet their employment targets, or create more or fewer jobs than anticipated.

This paper analyzes establishment error in estimating anticipated employment targets in startup and expansion projects. We compare actual employment when projects are operational to the anticipated employment targets reported by Ohio establishments that began operations or expanded facilities over a three-year period. Our primary objective is to examine the connection between employment projection error and establishment age. Drawing on the literature on firm learning, we hypothesize that, other things being equal, a negative relationship exists between employment projection error and establishment age. This is because older establishments are better informed of their underlying efficiency type, and this information decreases uncertainty about future costs and increases the accuracy of employment projections.

Jovanovic's (1982) passive firm learning model suggests that firms learn their underlying cost structure by observing noisy signals of their efficiency type over time. Firms that receive favorable efficiency signals learn that they are low cost producers, which may lead them to expand their operations. Firms that receive unfavorable signals learn that they are high cost producers, which may lead them to scale back their operations or exit the industry. The passive learning model implies that enterprise failure and growth rates decrease with the age of the establishment. A study of over 200,000 plants confirmed that failure and growth rates are negatively related to establishment age (Dunne et al., 1989). Evans (1987a, 1987b) also found that employment growth rates decrease with age in a study of over 20,000 manufacturing firms.

Final version accepted on September 20, 2001

Todd M. Gabe
Department of Resource Economics and Policy
University of Maine
200 Winslow Hall
Orono, ME 04469-5782
U.S.A.
E-mail: todd.gabe@umit.maine.edu

David S. Kraybill
Department of Agricultural, Environmental, and Development Economics
The Ohio State University
Agricultural Administration Building, Room 340
2120 Fyffe Road
Columbus, OH 43210
U.S.A.
E-mail: kraybill.1@osu.edu

Small Business Economics **21**: 19–26, 2003.

In contrast with previous applications of passive learning theory, this paper focuses on the accuracy of establishments' employment projection. The analysis suggests that old establishments more accurately predict future employment levels than young businesses, providing evidence consistent with passive firm learning. Section 2 presents a conceptual model that links an establishment's employment projection accuracy to establishment age through a process of passive firm learning. The data used in the study are discussed in Section 3. Section 4 presents empirical results that indicate an increase of ten years in establishment age is associated with a decrease in employment projection error rate of between 11 and 13 percentage points. In Section 5, we examine the factors that affect the accuracy of employment projections in establishments that surpassed or met their employment targets and establishments that fell short of their employment targets. The paper concludes in Section 6.

2. Model of employment projection error

Consider a two-period model in which establishments start projects and announce employment targets in period $t = 0$, and projects are operational in period $t = 1$. Establishments are assumed to operate at profit-maximizing employment levels in each period:

$$S_{i,\,t} = f(\gamma_{i,\,t},\ \omega_{i,\,t}), \tag{1}$$

where $S_{i,\,t}$ is an establishment's employment level, $f(.)$ is a linear employment function, $\gamma_{i,\,t}$ is an establishment's efficiency signal, and $\omega_{i,\,t}$ represents other revenue and cost conditions relevant to the establishment. Before a project's start in $t = 0$, the establishment reports an estimate of its anticipated employment target when the project is operational in $t = 1$:

$$S^{*}_{i,\,t=1} = f[E_{i,\,t}(\gamma_{i,\,t+1}),\ E_{i,\,t}(\omega_{i,\,t+1})]_{t=0}, \tag{2}$$

where $S^{*}_{i,\,t}$ is an establishment's anticipated employment target, and $E_{i,\,t}(.)$ is an establishment's expectation in period t of future conditions. An establishment's error in estimating its anticipated employment target is represented as $|(S^{*}_{i,\,t=1} - S_{i,\,t=1})/S^{*}_{i,\,t=1}|$ and referred to as an establishment's employment projection error rate. A decrease in an establishment's employment projection error rate corresponds with an increase in its accuracy in estimating its anticipated employment target.

One factor that affects an establishment's employment projection error rate is its accuracy in estimating future efficiency signals, represented as $|[E_{i,\,t}(\gamma_{i,\,t+1})]_{t=0} - \gamma_{i,\,t=1}|$. An establishment's efficiency signal, which determines its production costs in each period, is comprised of a constant and unknown parameter of its efficiency type, θ_i, drawn from a distribution of all establishments in an industry and a white noise parameter, $\varepsilon_{i,\,t}$, where:

$$\gamma_{i,\,t} = \theta_i + \varepsilon_{i,\,t}, \tag{3}$$

with $\varepsilon_{i,\,t} \sim N(0, \sigma^2)$ (Jovanovic, 1982). Establishments are assumed to base $[E_{i,\,t}(\gamma_{i,\,t+1})]_{t=0}$ on $E_{i,\,t=0}(\theta_i)$, which is based on their observations of past efficiency signals. An implication of passive learning is that establishments learn their efficiency type through production experience and, therefore, $|E_{i,\,t=0}(\theta_i) - \theta_i|$ and $|[E_{i,\,t}(\gamma_{i,\,t+1})]_{t=0} - \gamma_{i,\,t=1}|$ are negatively related to an establishment's level of experience. Thus, using establishment age as a measure of its experience, older establishments are expected to be more accurate in estimating anticipated employment targets than younger establishments.

An establishment's accuracy in predicting other future revenue and cost conditions also affects its employment projection error rate. The factors included in $|[E_{i,\,t}(\omega_{i,\,t+1})]_{t=0} - \omega_{i,\,t=1}|$ are an establishment's accuracy in estimating industry market conditions and economic conditions where the establishment is located. Although we do not specify particular processes to generate values of $\omega_{i,\,t}$, we assume that an establishment bases $E_{i,\,t}(\omega_{i,\,t+1})$ on recent trends in industry output and employment where the establishment is located. Higher variations in industry output and local employment over time correspond with larger values of $|[E_{i,\,t}(\omega_{i,\,t+1})]_{t=0} - \omega_{i,\,t=1}|$. Thus, establishments in industries with wide fluctuations in annual output are expected to be less accurate in estimating anticipated employment targets than establishments in industries with stable output over time. Likewise, establishments located in areas with wide fluctuations in annual employment are expected to be less accurate in estimating anticipated employment targets than establish-

ments located in areas with stable employment over time.

3. Data on employment projection error

The empirical study analyzes data from 442 Ohio establishments that began operations or expanded facilities between 1993 and 1995. The Ohio Department of Development compiles a list of startups and expansions that occur in the state and submits the list to *Site Selection* magazine, which compares economic development activities in states across the nation. Establishments must invest $1 million or more in new capital, undertake new building construction of 20,000 square feet or more, or add 50 or more new jobs to be included in the state's list of expansions and attractions. Thus, the data set consists of information regarding establishments that launched substantial projects and does not include information on small startups and expansions.

The data were collected in a questionnaire sent to 1,000 establishments that started projects between 1993 and 1995. The survey, conducted during the first half of 1997, targeted establishments whose projects involved the creation of new jobs. The data collection process, which followed Dillman's (1978) "Total Design Method," involved an initial mail survey sent to all 1,000 businesses and two follow-up surveys mailed to non-respondents. Approximately 50 percent of the establishments responded to the survey.

An establishment's employment projection error rate is measured as the absolute difference between its employment level two years after a project is announced and its anticipated employment target, divided by the establishment's anticipated employment target. We do not have information on the time when an establishment estimated its project would be operational; however, we assume that projects are operational two years after they are announced. The Ohio Department of Development reports an establishment's anticipated change in employment rather than its employment target when a project is operational. Anticipated employment targets, which are used to calculate the error rates, are computed as an establishment's anticipated change in employment added to its employment level at the start of a project.

The anticipated job creation figures compiled by the Ohio Department of Development are based on multiple sources including the personal knowledge of the department's personnel located in regional offices, newspaper accounts, and reports submitted by local development organizations. Approximately 30 percent of the establishments received assistance from one or more economic development incentive programs administered by the state. Businesses may have received incentives from local programs as well.

Descriptive statistics and industrial classifications of the 442 establishments included in the sample are presented in Tables I and II. The average establishment employed 373 workers two years after starting a project, compared to an average anticipated employment target of 392 employees. The average absolute difference between an establishment's employment level two years after starting a project and its anticipated employment target is 68 employees and the average employment projection error rate is 0.54.

Independent variables used to explain variations in employment projection error rates are establishment age, establishment size and second-order age and size variables. Establishment age is measured as the number of years an establishment had been in operation as of 1997 and establishment size is measured as its employment level the year a project is announced. We control for the receipt of an incentive with a dummy variable that equals one if the establishment received assistance from one or more incentive programs administered by the state, and that equals zero otherwise. The incentive variable is included because of the possibility that establishments seeking state assistance may intentionally overestimate future employment in an effort to obtain a larger subsidy (Gabe and Kraybill, 2001). Incentive programs considered in the paper are the Ohio Job Creation Tax Credit Program, the Ohio Industrial Training Program, the Business Development Account, the Roadway Development Account and the Community Development Block Grant Discretionary Fund.

The empirical models also include variables to control for an establishment's uncertainty about future industry and local economic conditions. For manufacturing establishments, uncertainty about industry conditions is represented by the coeffi-

TABLE I
Descriptive statistics of establishments that launched startup and expansion projects

Variable	Mean	Standard deviation
Employment projection error rate	0.543	0.996
Establishment's anticipated employment target	392	1,079
Establishment's employment two years after project was announced	373	1,103
Age (establishment age measured from 1997)	21	26
Size (establishment employment when project was announced)	317	1,032
Incentive (equals one if establishment received assistance from one or more state-sponsored incentive programs, and zero otherwise)	0.292	NA
Market fluctuations (coefficient of variation of annual output in establishment's industry at the national level between 1990 and 1997)	0.161	0.060
Local fluctuations (coefficient of variation of annual employment in establishment's county between 1990 and 1997)	0.065	0.043
Number of observations	442	

TABLE II
Industrial classifications of establishments that launched startup and expansion projects

Industry	Percentage of establishments
Services (SIC 70–97)	3.3
FIRE (SIC 60–67)	1.4
Wholesale and retail trade (SIC 50–59)	9.7
Transportation and public utilities (SIC 40–49)	1.6
Food and kindred products (SIC 20)	4.8
Textiles (SIC 22–23)	0.7
Lumber, wood, furniture and fixtures (SIC 24–25)	2.3
Paper and allied products (SIC 26)	4.5
Printing and publishing (SIC 27)	3.4
Chemicals and petroleum products (SIC 28–29)	4.3
Rubber and plastic products (SIC 30)	9.6
Leather products (SIC 31)	0.5
Stone, clay and glass products (SIC 32)	4.3
Primary metal industries (SIC 33)	6.3
Fabricated metal products (SIC 34)	10.2
Industrial machinery and equipment (SIC 35)	16.5
Electronic equipment (SIC 36)	5.2
Transportation equipment (SIC 37)	9.0
Instruments and related products (SIC 38)	1.1
Miscellaneous manufacturing (SIC 39)	1.1
Number of observations	442

cient of variation of industry shipments in the United States between 1990 and 1997 at the four-digit SIC level. Uncertainty about industry conditions in non-manufacturing sectors is measured as the coefficient of variation of annual industry output in the United States between 1990 and 1997 at the two-digit SIC level. Industry output and shipment data are from the Bureau of Economic Analysis. Uncertainty about local economic conditions is represented by the coefficient of variation of annual employment in the establishment's county between 1990 and 1997. Employment figures for Ohio counties are from County Business Patterns data published by the United States Bureau of the Census.

4. Econometric estimation and results

Tables III and IV present findings from four empirical models of employment projection error. The dependent variable in each model is an establishment's employment projection error rate and several combinations of explanatory variables are used to isolate the relationship between employment projection error and establishment age. Model 4 includes a set of dummy variables to control for industry effects on an establishment's employment projection error. The 442 establishments in the sample are separated into 20 industries as shown in Table II and the chemicals and petroleum products industry is the omitted category in the empirical analysis.

TABLE III
OLS regression results: factors affecting employment projection error

Dependent variable: Employment projection error rate			
Variable	Model 1	Model 2	Model 3
Age	–0.019** (–3.913)[a]	–0.015** (–3.101)	–0.016** (–3.155)
Age^2	1.340E-04** (2.856)	1.087E-04** (2.234)	1.118E-04** (2.298)
Size		–3.193E-04** (–2.241)	–3.175E-04** (–2.225)
Size^2		2.607E-08* (1.732)	2.667E-08* (1.769)
Age × Size		8.627E-07 (0.664)	7.386E-07 (0.568)
Incentive			0.101 (0.974)
Market fluctuations			–1.051 (–1.351)
Local fluctuations			–1.105 (–1.019)
Constant	0.787** (10.830)	0.806** (11.050)	1.020** (5.928)
R-squared	0.042	0.054	0.064
Adjusted *R*-squared	0.038	0.044	0.046
F-value	51.982	27.098	18.592
Number of observations	442	442	442

[a] *t*-statistics listed in parentheses.
* Indicates variable is significant at the 10 percent level.
** Indicates variable is significant at the 5 percent level.

Results from all four models indicate that an establishment's employment projection error rate is negatively related to establishment age. This suggests old establishments more accurately predict anticipated employment targets than young businesses. Since the models include second-order age variables, the marginal effect associated with establishment age is calculated as the partial derivative of the employment projection error rate with respect to age for each sample observation.

The marginal effect of establishment age on the employment projection error rate is –0.013 (*F*-statistic = 15.302; *p*-value = 0.0001), –0.011 (*F*-statistic = 9.611; *p*-value = 0.002), –0.011 (*F*-statistic = 9.949; *p*-value = 0.002) and –0.011 (*F*-statistic = 8.965; *p*-value = 0.003) in models 1 to 4, respectively. This suggests that an establishment with ten more years experience than average has between an 11 and 13 percentage point lower employment projection error rate than the average establishment. Partial derivatives of the employment projection error rate with respect to establishment age, calculated using the estimates from models 1 to 4, are less than zero in more than 93 percent of the sample observations in each of the models.

The marginal effect of establishment size on the employment projection error rate is –0.00028 (*F*-statistic = 5.020; *p*-value = 0.026), –0.00029 (*F*-statistic = 4.950; *p*-value = 0.027) and –0.00022 (*F*-statistic = 2.511; *p*-value = 0.114) in models 2, 3 and 4. This suggests an establishment with one hundred more workers than average has a two to three percentage point lower employment projection error rate than the average establishment. The partial derivatives of an establishment's

TABLE IV
OLS regression results: factors affecting employment projection error, controlling for establishment industry

Dependent variable: Employment projection error rate		
Variable	Model 4	
	Estimated coefficient	*t*-statistic
Age	–0.015**	–2.995
Age^2	9.552E-05*	1.896
Size	–2.423E-04	–1.584
Size^2	2.074E-08	1.331
Age × Size	5.810E-07	0.433
Incentive	0.052	0.489
Market fluctuations	–0.886	–0.950
Local fluctuations	–1.197	–1.071
Services	0.339	0.974
FIRE	–0.199	–0.419
Wholesale and retail trade	–0.268	–0.986
Transportation and public utilities	0.282	0.649
Food and kindred products	–0.187	–0.603
Textiles	0.049	0.080
Lumber, wood, furniture and fixtures	–0.323	–0.838
Paper and allied products	0.397	1.255
Printing and publishing	–0.390	–1.156
Rubber and plastic products	–0.099	–0.367
Leather products	0.539	0.738
Stone, clay and glass products	0.173	0.541
Primary metal industries	–0.038	–0.130
Fabricated metal products	–0.282	–1.049
Industrial machinery and equipment	–0.074	–0.284
Electronic equipment	–0.235	–0.765
Transportation equipment	–0.254	–0.850
Instruments and related products	–0.186	–0.376
Miscellaneous manufacturing	–0.250	–0.506
Constant	1.122**	4.114
R-squared	0.101	
Adjusted *R*-squared	0.042	
F-value	6.565	
Number of observations	442	

* Indicates variable is significant at the 10 percent level.
** Indicates variable is significant at the 5 percent level.

employment projection error rate with respect to size, calculated using the estimates from models 2, 3 and 4, are less than zero in approximately 99 percent of the sample observations in each of the models.

The empirical results from models 3 and 4 do not provide evidence of a signification relationship between employment projection error and an establishment's receipt of an incentive. Findings from models 3 and 4 do not indicate that fluctuations in industry output or local employment significantly affect employment projection error. Finally, none of the industry dummy variables have a significant effect on employment projection error in model 4 and the 19 industry dummy variables are jointly insignificant as well (*F*-statistic = 0.905; *p*-value = 0.576).

5. Error of overachievers and underachievers

The empirical results presented in Section 4 are estimated from a sample of establishments whose project outcomes varied widely. Six establishments in the sample exactly met their anticipated employment targets, 297 created fewer jobs than anticipated and 139 met or surpassed their anticipated employment targets. In this section, the sample is separated into two parts to focus on employment projection error in establishments with similar project outcomes. One part includes 145 establishments that met or exceeded their anticipated employment targets, referred to as overachievers, and the other part includes 297 establishments that fell short of their anticipated employment targets, referred to as underachievers.

Descriptive statistics shown in Table V reveal several differences between the samples of overachievers and underachievers. The average employment projection error rate of overachievers is 0.184, compared to an average error rate of 0.719 for underachievers. Thus, underachievers fell short of their employment targets by a larger margin (relative to the size of employment targets) than the margin by which overachievers surpassed their targets. Furthermore, overachievers are generally younger in age and they employed more workers at the start of projects than underachievers.

Regression results from the samples of overachievers (model 5) and underachievers (model 6) are shown in Table VI. The goodness-of-fit measures are higher in models 5 and 6 than in model 3, which uses the same explanatory variables but combined rather than segmented samples of overachievers and underachievers. The marginal effect of ten additional years of establishment age for an underachieving enterprise is

TABLE V
Descriptive statistics of overachievers and underachievers

Variable	Mean values	
	Overachievers	Underachievers
Employment projection error rate	0.184	0.719
Establishment's anticipated employment target	571	304
Establishment's employment level two years after project was announced	645	240
Age	18	22
Size	510	223
Incentive	0.283	0.296
Market fluctuations	0.168	0.157
Local fluctuations	0.071	0.062
Number of observations	145	297

TABLE VI
OLS regression results: factors affecting employment projection error of overachievers and underachievers

Dependent variable: Employment projection error rate		
Variable	Model 5	Model 6
Age	–5.493E-03** (–3.179)[a]	–0.021** (–2.957)
Age^2	3.390E-05* (1.938)	1.484E-04** (2.269)
Size	–6.716E-05* (–1.704)	–4.917E-04** (–2.055)
$Size^2$	4.384E-09 (1.195)	8.076E-08 (1.221)
Age × Size	5.875E-07 (1.421)	–2.332E-06 (–0.471)
Incentive	7.284E-03 (–0.223)	0.138 (0.945)
Market fluctuations	–0.104 (–0.470)	–1.165 (–0.994)
Local fluctuations	–0.356 (–1.088)	–0.711 (–0.453)
Constant	0.312** (5.952)	1.275** (5.110)
R-squared	0.162	0.085
Adjusted *R*-squared	0.113	0.059
F-value	21.695	15.901
Number of observations	145	297

[a] *t*-statistics listed in parentheses.
* Indicates variable is significant at the 10 percent level.
** Indicates variable is significant at the 5 percent level.

a decrease of approximately 14 percentage points (*F*-statistic = 8.739; *p*-value = 0.003) in its employment projection error rate. The marginal effect of ten additional years of establishment age is a decrease in an overachiever's employment projection error rate of approximately four percentage points (*F*-statistic = 10.104; *p*-value = 0.002). This is a smaller effect than computed from the combined sample in model 3.

The marginal effect of one hundred additional workers in an underachieving enterprise is a decrease of approximately five percentage points (*F*-statistic = 4.224; *p*-value = 0.041) in its employment projection error rate. Similarly, the marginal effect of one hundred additional workers is a decrease in an overachiever's employment projection error rate of approximately five percentage points (*F*-statistic = 2.903; *p*-value = 0.091). Consistent with the results from models 3 and 4, the employment projection error rates of underachievers and overachievers are not significantly related to the receipt of an incentive, variations in industry output, or variations in local employment.

6. Discussion and conclusions

Establishment startup and expansion projects are key sources of employment growth in many regions across the United States. The Ohio Department of Development collected information on approximately 2,400 projects launched in Ohio between 1993 and 1995, which were projected to

create an anticipated 112,000 new jobs when the projects were operational. The number of jobs actually created in these projects, however, differed from the anticipated employment targets announced for these projects. This paper presents empirical evidence on the factors that affect an establishment's employment projection error and investigates whether old establishments more accurately predict future employment targets than young businesses.

Our analysis links employment projection error to an establishment's uncertainty about future efficiency signals associated with passive firm learning. Numerous previous studies have analyzed the effects of uncertainty on firm growth (Bar-Ilan and Strange, 1996; Cabral, 1995; Dixit, 1989, 1997; Pindyck, 1982). In these models, uncertainty affects firm behavior because project investments are fixed and irreversible. We assume in this paper that labor is a flexible factor of production. This is consistent with Pindyck (1982), although Oi (1962) and Dixit (1997) treat labor as a quasi-fixed factor of production. With labor as a flexible factor, an establishment bases its employment level on conditions experienced in each period. Uncertainty affects employment projection error because anticipated employment targets are based on an establishment's expectations about future conditions, whereas employment levels when projects are operational are based on actual conditions experienced by the establishment.

In conclusion, our empirical results suggest that employment projection error rates associated with business startups and expansions tend to be negatively related to establishment age, other things being equal. In four of the six models estimated in the paper, an increase in establishment age of ten years is associated with a decrease in its employment projection error rate of between 11 and 13 percentage points. These findings support the hypothesis that old establishments predict future employment targets more accurately than young businesses.

Acknowledgements

We would like to acknowledge the helpful comments received from two reviewers. Financial support for this study was provided by the National Research Initiative of the United States Department of Agriculture. This is MAFES External Publication #2510.

References

Bar-Ilan, A. and W. Strange, 1996, 'Investment Lags', *American Economic Review* **86**, 610–622.

Cabral, L., 1995, 'Sunk Costs, Firm Size and Firm Growth', *Journal of Industrial Economics* **43**, 161–172.

Dillman, D., 1978, *Mail and Telephone Surveys: The Total Design Method*, New York: John Wiley and Sons.

Dixit, A., 1989, 'Entry and Exit Decisions under Uncertainty', *Journal of Political Economy* **97**, 620–638.

Dixit, A., 1997, 'Investment and Employment Dynamics in the Short Run and the Long Run', *Oxford Economic Papers* **49**, 1–20.

Dunne, T., M. Roberts and L. Samuelson, 1989, 'The Growth and Failure of U.S. Manufacturing Plants', *Quarterly Journal of Economics* **104**, 671–698.

Evans, D., 1987a, 'Tests of Alternative Theories of Firm Growth', *Journal of Political Economy* **95**, 657–674.

Evans, D., 1987b, 'The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries', *Journal of Industrial Economics* **35**, 567–581.

Gabe, T. and D. Kraybill, 2001, 'The Effect of Economic Development Incentives on Establishment Growth', unpublished manuscript.

Jovanovic, B., 1982, 'Selection and the Evolution of Industry', *Econometrica* **50**, 649–670.

Oi, W., 1962, 'Labor as a Quasi-Fixed Factor', *Journal of Political Economy* **70**, 538–555.

Pindyck, R., 1982, 'Adjustment Costs, Uncertainty, and the Behavior of the Firm', *American Economic Review* **72**, 415–427.