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Survival Analysis of Incubated Firms in Maryland USA: Empirical Evidence of the Effectiveness of Business Incubation

Roundtable 2

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Executive summary

Published statistics and quantitative analysis of incubator firm survival are limited, yet this information is critically important for incubator directors to report on the effectiveness of incubation as an economic development intervention to funding organizations. Using a unique establishment-level panel data provided by a commercial vendor (National Establishment Time-Series [NETS], Maryland State File), we develop a discrete-time survival analysis to examine how business incubators influence the length of years firms survive post incubation. Participation in an incubator program is associated with economically and statistically significant decrease in the risk firm failure. Our findings suggest that the odds of failing or closing are *7 times lower* when a firm participated in an incubator program, even when controlling for industry, firm age, and years of operation post graduation.

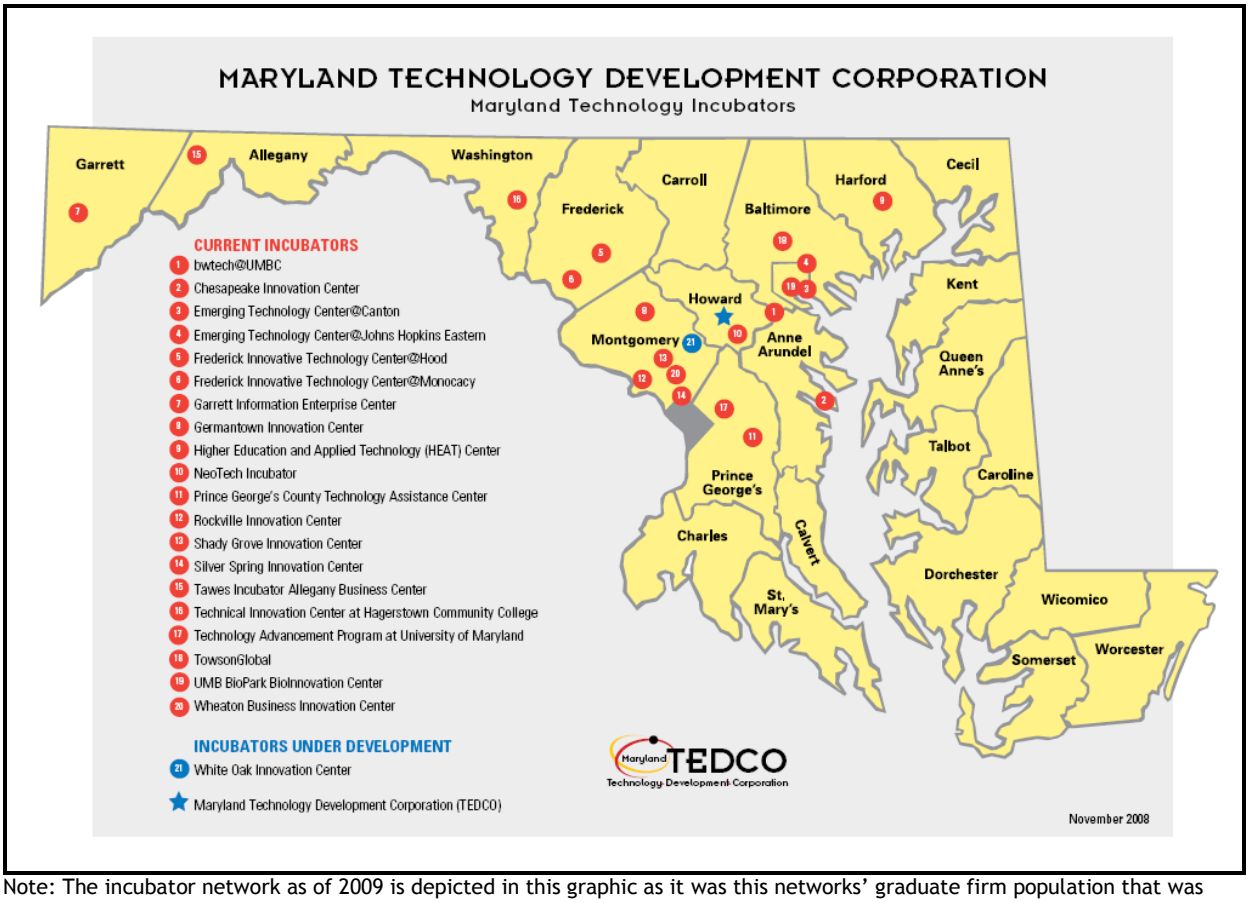
Introduction

Investors in business incubation programs—government agencies, universities, non-profit organizations and foundations, generally—require incubator directors to assess the effectiveness of incubation and incubation programs. Incubator directors may respond with data on "graduated" firms, employment, and measures of scientific and commercial success, but inevitably the question is raised as to whether graduates would have been successful even if they had not participated in the incubation program. Case studies of phenomenally successful firms do occur and capture media spotlight, but they are more the exception than the rule.

Incubator sponsors are often in the position of defending their programs against detractors seeking statistical evidence supporting claims of incubator effectiveness. Although the incubation community has long been interested in understanding the success rates of incubated firms using experimental methods, published statistics and rigorous quantitative analysis of incubated firm survival are limited because of the difficulty of employing empirical methods and collecting data on a sufficiently large number of graduates. Consequently, very little statistical information is presently available to allow us to state definitely whether business incubation programs are effective at helping businesses stay in operation, relative to whether they had not located in an incubator.

This paper presents statistical evidence on the effectiveness of incubation that overcomes this data gap, providing results from the US state of Maryland's business incubation network (Figure 1) showing that incubators are not only successful but that the firms that they support are more than 7 times as likely as their non-incubated peers (matched by age and industry) to survive over the long-term. In response to questions posed to us by incubator directors seeking empirical evidence that further validate business incubation as an economic development intervention, we employed survival analysis to study whether incubated firms were more likely to stay in business relative to peer firms (matched by industry and age) that were not incubated.

Figure 1. Maryland's Business Incubator Network, as of 2009



Note: The incubator network as of 2009 is depicted in this graphic as it was this networks' graduate firm population that was analyzed in our statistical analysis. See also Table 1. Graphic courtesy of the Maryland Technology Development Corporation.

Background and Literature Review

Published statistics and quantitative analysis of incubator firm survival are limited. The National Business Incubator Association (NBIA) provides a qualitative comparison of survival rates using publicly available Small Business Administration enterprise data; but by their own admission, the comparison does not provide an appropriate evaluation of incubator effects (NBIA, 2009).

In the science park literature, survival outcome results have been mixed. Westhead and Storey (1994) found that British firms locating on science parks did not have higher survival rates. In contrast, Ferguson and Olofsson (2004) found higher survival rates for a sample of on-park Swedish companies compared to off-park firms.

Recent evaluation literature has tried to address this gap by using matched-pair analysis and data sets that follow firms over time. For example, (Siegel, Westhead, and Wright 2003) compared research productivity measures for on/off science park firms that we matched by age, industry, ownership status, and region. They found that firms located on science parks had higher research productivity than comparable off-science park firms. Rothaermel and Thursby (2005) use a longitudinal data set to study how university links influences failure and graduation time at a single U.S. technology incubator. Results showed that university links were associated with higher success rates; however, they also increased the time a firm spent in the incubator.

Phan, Siegel, and Wright (2005) have also suggested future work that uses survival analysis[1] could provide new insights about the incubated firm survival rates. Although survival analysis has already been successfully used to study the effect of longevity and productivity of buyouts (Phan, Siegel, and Wright 2005) and more recently explores *post-graduation* survival rates (Schwartz 2009), to our knowledge, survival analysis has not been used to measure and *compare* survival rates of incubated establishments with a matched group of non-incubated establishments.

Motivation

Our incubated-firm survival analysis was performed by analyzing the known universe of 357 firms that had graduated from technology incubators in the U.S. state of Maryland as of June 2007. Graduate firms from Maryland technology incubators were selected for study because we had acquired as comprehensive a list as possible when supporting colleagues at RTI who had been engaged by the Maryland Technology Development Corporation (TEDCO) to assess Maryland's capacity for additional technology incubators. Under that engagement, we collected a substantial amount of data on Maryland's technology incubators, including lists of existing incubator residents and graduated firms. Supporting the engagement were TEDCO, the Maryland Business Incubator Association (MBIA), and the technology incubators.

The Maryland TEDCO was established in 1998 by the Maryland General Assembly to support Maryland-based technology start-ups and to facilitate transfer and commercialization of technology developed at Maryland research universities and government laboratories.[2] Maryland's technology incubators are not operated by TEDCO. Rather, they are individually operated by several research universities and local economic development authorities. Among TEDCO's programs, however, are three designed to support business incubators: an incubator feasibility study grant program, an incubator development fund providing matching capital funds for new incubator development, and annual business and support assistance to incubators and resident companies. The MBIA, the state incubator association, provides a forum for incubator managers and boards to confer. The MBIA also collects activity data from each incubator member semiannually, and provides reports and summary data to TEDCO to assist in measuring activity.

As in the literature, a recurrent topic of discussion over the course of the engagement were the many challenges of ascertaining the extent to which incubation made an incubated firm a more viable concern, as measured by its post graduation survival, relative to a control firm of the same approximate age and industry that did not enter an incubator. The method presented in this paper emerged as one possible approach for investigating this question retrospectively in the absence of resources or ex ante planning to conduct a matched-pair experiment.

To our knowledge, duration analysis has not been used to measure and compare survival rates of incubated/non-incubated firms. The data source for our establishment survival analysis is the National Establishment Time-Series (NETS) Database. Using an existing list of Maryland incubated firms and a subscription to the NETS Maryland State File, we merged and compiled information for establishments with similar age and industry characteristics. We used discrete-time duration analysis to examine the potential influence incubator exposure has on the length of years an establishment stays in operation in Maryland.

[1] Different disciplines have alternative names and include duration analysis and event history analysis.

[2] http://www.marylandtedco.org/abouttedco/index.cfm

Table 1. Maryland's Business Incubators Operating in 2009.

Incubator	County	Targeted Industries
Tawes Incubator Allegany Business Center	Allegany	Biotech, IT, Environmental Science, Educational Software
Chesapeake Innovation Center	Anne Arundel	Homeland and National Security
Emerging Technology Center @ Johns Hopkins Eastern Emerging Technology Center @ Canton	Baltimore	General High-tech, Biotech
Techcenter @ UMBC	Baltimore	General High-tech, Bioscience
TowsonGlobal (new)	Baltimore	International companies, Domestic companies seeking international markets
University of Maryland-Baltimore	Baltimore	Life Sciences
Frederick Innovative Technology Center, Inc. @ Hood Frederick Innovative Technology Center, Inc. @ Monocacy	Frederick	IT, Biotech
Garrett Information Enterprise Center	Garrett	General High-tech
Higher Education and Applied Technology Center	Harford	General High-tech
Neotech Incubator	Howard	General High-tech
Maryland Technology Development Center (Now Shady Grove Innovation Center)	Montgomery	General High-tech, Bioscience
Rockville Innovation Center (new)	Montgomery	International, Bioinformatics
Silver Spring Innovation Center	Montgomery	General High-Tech, Multi-media, Wireless
Prince George's County Technology Assistance Center	Prince George's	General High-tech
Technology Advancement Program at University of Maryland	Prince George's	General High-tech
Technical Innovation Center at Hagerstown Community College	Washington	Manufacturing, General High-Tech

Methods

Our incubated-firm survival analysis was performed by analyzing the known universe of nearly 300 firms that had graduated from technology incubators in the U.S. state of Maryland as of June 2007 for which data were available. Out of a population of 357 firms, we were unable to acquire histories for 60 firms. Our study uses a Maryland version of National Establishment Time-Series (NETS) database to identify a sample of over 14,500 possible peer establishments within the computer service provider industry (SIC 737).

NETS has been identified by the Kauffman Symposium on Entrepreneurship and Innovation Data as one of the emerging information sources about entrepreneurship and innovation (Walls 2007). We also maintain a list of computer service providers that participated in Maryland's business incubator program and use their Dun & Bradstreet's unique establishment number to match the establishment with their NETS record. The NETS record provides the first and last year that the establishment was active within Maryland we use the year variables to create a panel that describes each establishment's active status between 1990 and 2007.

Since we are most interested in post-incubation status, the panel record for incubated establishments were adjusted to reflect the first year of activity after leaving the incubator program. After the post-graduation panel is assembled, we use survival analysis to compare and contrast the life histories of incubated establishments with similar peer establishments that were not incubated.

Our interest is in the length of time an establishment stays in Maryland. It is important to distinguish between *periods* (years) within the life history (which are measured relative to the start date) and chronological years (1990 to 2007). Our empirical work is in terms of *periods*. For each establishment and period, there is an event indicator variable that is 0 if the establishment did not leave in that period and 1 if it did leave in that period. "Leaving" is defined as moving out of state or ceasing operations.

Since the sample period ends in 2007, we will not be able to observe the some of the establishments leave Maryland after 2007. Such observations are *right censored*[3]. For example, if we only observe an establishment start year of 2002 and it is still active through 2007, we know the life history lasted at least 5 years but not how long beyond that.

The establishment histories are described and summarized using the life table shown in Table 2. Column 1 labels the period (which lasts a year); each row label (1 through 16) refers to each period. Column 2 includes the number of establishments at the beginning of the period that could leave Maryland by the end of the period. Column 3 identifies the number of establishments that left Maryland during the period, and column 4 records the number of right-censored firms.

Table 2. Life Table Associated with Maryland Computer Service Providers (SIC 737): 1990 to 2007

	Number of Establishments			Proportion of	
Year	In Maryland at Beginning of Year	Left during the Year	Censored at the End of the Year	Beginning of the Year where Establishment Left during the Year	Establishments Still in Maryland at the End of the Year
–	14,776	–	–	–	100.0%
1	14,776	1,402	2	9.5%	90.5%
2	13,372	1,499	713	11.2%	80.4%
3	11,160	1,401	760	12.6%	70.3%
4	8,999	922	580	10.2%	63.1%
5	7,497	714	490	9.5%	57.1%
6	6,293	551	710	8.8%	52.1%
7	5,032	395	630	7.8%	48.0%
8	4,007	305	467	7.6%	44.3%
9	3,235	202	459	6.2%	41.6%
10	2,574	183	402	7.1%	38.6%
11	1,989	124	400	6.2%	36.2%
12	1,465	85	331	5.8%	34.1%
13	1,049	52	263	5.0%	32.4%
14	734	35	205	4.8%	30.9%
15	494	18	212	3.6%	29.7%
16	264	4	260	1.5%	29.3%

[3] For establishments starting before 1990, the beginning year will not be observed (i.e., the active spells beginning before 1990 are left censored). We do not consider left-censored spells; this is a common strategy adopted in survival analysis (Singer and Willet 2003).

As shown, the first period includes 14,776 active computer provide establishments (SIC 737) that could potentially leave Maryland during the sample period. By the end of the first period, 1,402 establishments either closed or re-located to a different state. In addition, 2 establishments exit the sample because they are right-censored. The two establishments began in 2006 and were not observed leaving after that year. The remaining 13,372 establishments are at "risk" of leaving during period two (14,766 −1,402 − 2 = 13,372). At the end of the second period, another 1,499 establishments had left Maryland and 713 establishments are right censored. During the last period, there were 264 establishments that started in 1990 that had not left Maryland by the end of 2005. Of those, 4 left during 2006 and 260 did not.

A common statistic used to summarize histories is the hazard $h(t_j)$. It describes the "risk of event occurrence" in each period among those eligible to experience the event (Singer and Willet 2003, 330). In the study's context, the hazard is the conditional probability that the establishments leaves Maryland, given that it has not left in the previous periods.

Participation in a Maryland business incubator program may increase an establishment's probability of remaining active. To assess the influence of incubator programs may have had on computer service providers, a binary outcome model for the probability (p) is used to describe establishment status for a given year in its life. The status variable (y) takes one of two values:

$$y = \begin{cases} 1 & \text{Not active: leave Maryland or close with probability} \quad p \\ 0 & \text{Active: stay or remain open with probability } 1-p \end{cases}.$$

The model for establishment (i) and period (j) is specified where p_{ij} depends on incubator participate and controls for other variables that influence the decision to leave the Maryland or close ($\mathbf{x}$).

$$p_{ij} \equiv \Pr\left(y_{ij} = 1 \middle| ib, \boldsymbol{x}\right) = F(\beta ib_i, \boldsymbol{x}_{ij}'\boldsymbol{\delta}).$$

The population parameter of interest is ß, the effect of the incubator participation on the response probability p_{ij}. Accurately measuring the incubator effect requires controlling for other variables that influence the decision to leave the Maryland. Although information is limited, we have include establishment size (employees) and macroeconomic trends in Maryland. To capture other time effects in a flexible way, we also have included period dummy variables as explanatory variables and excluded the constant term. Together the period dummies provide estimates of the baseline hazard function (expressed as fitted odds) and provide a time profile of the survival behavior for an average establishment.

Even after controlling for observables, we still acknowledge there may be unobserved factors that influence the decision to leave Maryland or close. The most obvious story is related to the self-selection problem; unobserved and intangible entrepreneurial skills that lead establishments to seek participation in an incubator program may also influence post-incubation success. Absent other detailed information, we have tried to alleviate the self-selection problem by controlling for establishment size[4] and including real gross domestic product [GDP] to control for time-varying economic factors that may influence the decision to Maryland or close and may be indirectly correlated with incubator participation.

[4] For establishment size, we calculated each establishment's highest employment level reported in NETS. Since all incubator establishments had fewer than 150 employees during their life history, we limited the peer group sample to establishments with 150 or fewer employees. There were 169 computer service provider establishments eliminated based on the 150 or fewer employee criteria. The remaining sample includes 14,776 establishments.

In a discrete-time binary choice hazard model, the establishment makes a decision each period about whether to leave Maryland. Such a model can use data for establishments do not leave Maryland during the sample period (i.e., "right-censored" firms). The logit model is a natural choice; the logistic cumulative distribution function Λ is

$$p = \Lambda(.) = \frac{e^{\beta ib + x'\delta}}{\left(1 + e^{\beta ib + x'\delta}\right)}$$

and the corresponding log-likelihood function is

$$LL(\beta, \boldsymbol{\delta}) = \sum_1^N y_{ij} \ln\left(\frac{e^{\beta ib_{ij} + \mathbf{x}'_{ij}\delta}}{\left(1 + e^{\beta ib_{ij} + \mathbf{x}'_{ij}\delta}\right)}\right) + \left(1 - y_{ij}\right)\ln\left(1 - \frac{e^{\beta ib_{ij} + \mathbf{x}'_{ij}\delta}}{\left(1 + e^{\beta ib_{ij} + \mathbf{x}'_{ij}\delta}\right)}\right).$$

The natural log of the odds ratio (ln(p/(1 − p)) is a linear function of the explanatory variables and estimated parameters. Taking the exponential of the coefficients yields the variable's marginal effect on the odds ratio.

Table 3. Discrete-Time Hazard Model Results

	Odds Ratio	p-value
Incubator participation (ß)		
1= Yes; 0=No	0.138	0.048
Control Variables		
Highest Reported Establishment Employees	0.985	<0.001
Ln(state real gdp)	0.805	<0.001
Time Period Dummies		
D_1	0.331	<0.001
D_2	0.406	<0.001
D_3	0.469	<0.001
D_4	0.378	<0.001
D_5	0.354	<0.001
D_6	0.329	<0.001
D_7	0.296	<0.001
D_8	0.290	<0.001
D_9	0.236	<0.001
D_{10}	0.275	<0.001
D_{11}	0.243	<0.001
D_{12}	0.227	<0.001
D_{13}	0.196	<0.001
D_{14}	0.190	<0.001
D_{15}	0.146	<0.001
D_{16}	0.061	<0.001
Number of Establishments	14,776	
Number of Observations	82,940	
Log-Likelihood (LL)	−25,726	

Technical Results

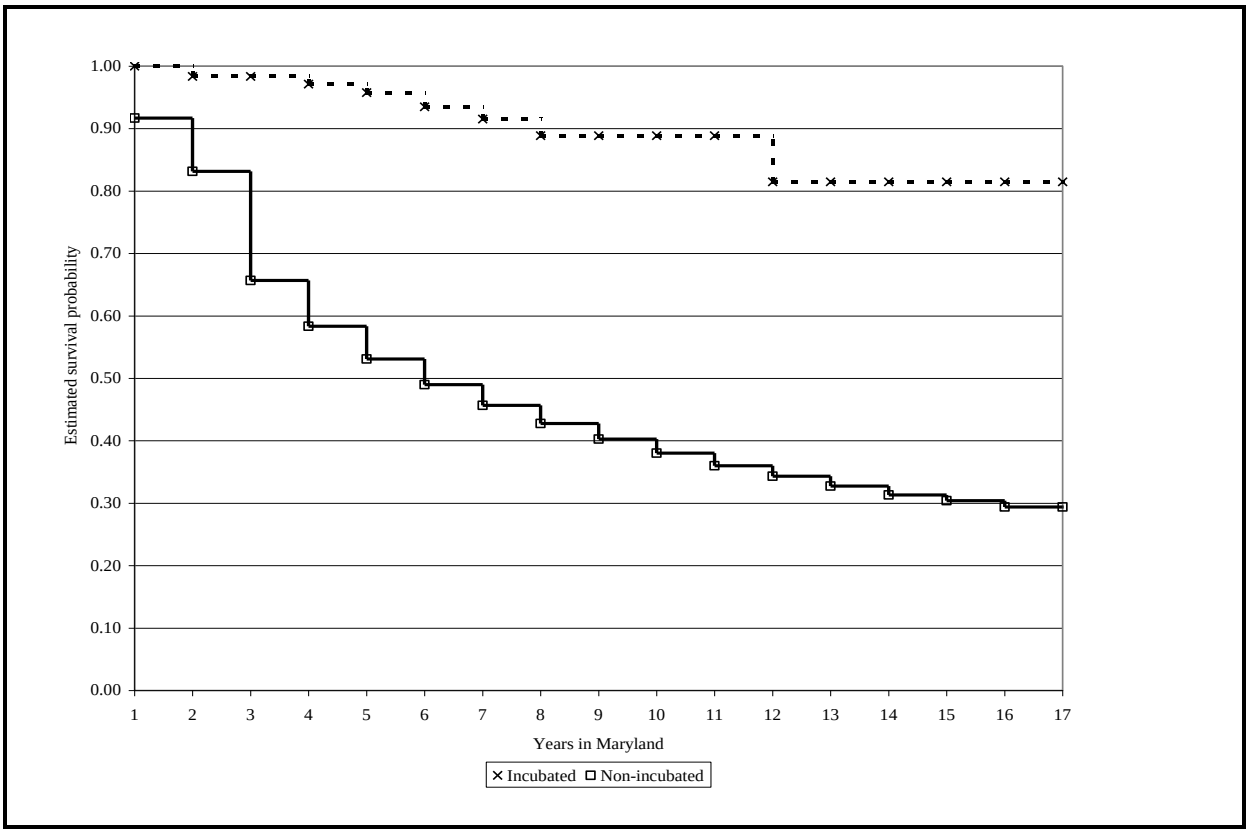
In technical terms, our central estimate of the odds ratio (0.137) suggests that the odds of leaving are 7 times lower when an establishment participated in an incubator program (Table 3). Incubator participation appears to reduce the likelihood that an establishment leaves Maryland. Although the estimate is statistically different than zero, the estimate is not precisely measured. Using the estimated standard errors for the model's coefficients and assuming a 95 percent confidence interval, the odds ratio could fall within a wide range (0.019 to 0.908). Other results suggest the odds of leaving are smaller if the establishment is larger (Figure 1). One additional employee reduces the odds ratio by about 2 percent. As expected, higher state GDP growth rates significantly reduces the odds of leaving. A one percent increase in state GDP reduces the odds ratio by 19 percent.

Practical Results and Discussion

Participation in an incubator program is associated with economically and statistically significant decrease in the risk of leaving Maryland (either by firm failure or by moving to another state). Our findings suggest that the odds of failing or closing are *7 times lower* when a firm participated in an incubator program, even when controlling for industry, firm age, and years of operation post graduation. Incubator participation reduces the likelihood that an establishment leaves Maryland.

Results are possible for Maryland because of the long history of business incubation in the state and the large number of graduates. However, the conclusion is that over long-term, incubators are indeed successful at promoting firm survival and success.

Figure 2. Comparison of Incubated Firms Survival Rates to Non-Incubated Firm Survival Rates Over Time in the US State of Maryland



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