State Government Innovation Programs and the Retention of Science and Technology Startups: Evidence from the Great Lakes Region

Bo Zhao

Faculty of Business and Economics

University of Hong Kong

Arvids A. Ziedonis

Management Science and Engineering Department

School of Engineering

Stanford University

Rosemarie H. Ziedonis

Lundquist College of Business

University of Oregon

Preliminary and Incomplete: Please Do Not Cite or Quote

This Draft: March 9, 2015

Abstract

Many new science and technology companies originate from hospitals, research labs, and industry incumbents that are geographically dispersed across many U.S. states. Yet the financial and human capital often required for commercialization is concentrated in certain regions. Based on evidence from Great Lakes states from 1990 to 2010, this study investigates the baseline proclivity of life sciences and information technology (IT) startups to leave their states of initial incorporation as well as the impact of state government innovation programs on retaining them. Overall, the evidence implies that startups with higher motivation to pursue growth capital and other resources are more likely to relocate from their home states. More interestingly, we find that startups in both industries are less likely to relocate after a major entrepreneurial program launch. By narrowing our focus to state innovation programs that are targeted toward life sciences startups, our difference–in–differences estimation suggests that the hazard rate of out–migrations among life sciences startups falls significantly following the launch of innovation program and the program retention effect is more pronounced among young life science startups but not growing companies. This study deepens our understanding of technology companies' mobility and provides the first systematic evidence that policy interventions at the regional level can significantly alter the geographic movement of entrepreneurial firms.

This research has been generously supported by the Ewing Marion Kauffman Foundation and the University of Michigan Rackham Predoctoral Fellowship. We are grateful to Mercedes Delgado, Francine Lafontaine, Tom Lyons, Jagadeesh Sivadasan, and Brian Wu for helpful comments. We thank the Institute for Exceptional Growth Companies of the Edward Lowe Foundation for data access.

1 Introduction

Many new science and technology companies originate from hospitals, research labs, and industry incumbents that are geographically dispersed across the U.S. Yet the financial and human capital often required for commercialization is often concentrated in distant financial and knowledge centers (Chen et al. 2010, Feldman and Francis 2004). For entrepreneurial firms located outside of these regions, the decision to remain in the locale of their founding can pose difficult trade–offs, particularly in sectors that require external financing and support during the commercialization process. Remaining in a home region allows an entrepreneur to leverage interpersonal networks and existing organizational ties (e.g., with universities or other research institutions) while avoiding the disruptions and costs of relocation (Dahl and Sorenson 2012, Feldman and Francis 2004). Yet, failure to move could make it more difficult or costly to secure expansion capital, management talent, or business services (Chen et al. 2010, Hochberg et al. 2007, Porter and Stern 2001). Indeed, Stuart and Sorenson (2003a) find that the local conditions that promote new venture creation often differ from those that maximize the performance of recently established companies.

Despite evidence that entrepreneurs who remain in their home regions enjoy a higher likelihood of survival and greater profitability (Dahl and Sorenson 2012), anecdotes of business relocations are plentiful. Consider, for example, BlueWare, an information technology company founded in Cadillac, Michigan. When CEO Rose Harr decided to expand and hire an additional 190 skilled workers, she moved the company to Florida, leaving behind close family and business contacts (Lovy 2012). Perhaps due to the difficulty of tracking mobility by entrepreneurial firms with census data, however (Lee 2008), systematic empirical evidence on the relocations of new science and technology companies has been less prevalent.

In this study, we utilize the National Establishment Time Series (NETS) dataset, which is based on Dun and Bradstreet (D&B) data, to track mobility of more than forty thousand life sciences and information technology companies initially located in five Great Lakes states, Indiana, Illinois, Michigan, Ohio, and Wisconsin, from the period of 1990 to 2010. Our empirical strategy has three parts. First, we use both non–parametric and semi–parametric methods to track the baseline proclivity of startup outmigration over the twenty year period. Consistent with the view that science and technology startup mobility is likely to be motivated by access to financial and other commercialization resources, our results show that firms in the life sciences, a sector associated with a strong need for access to external financial and scientific resources (Hall and Lerner 2010) are more likely to relocate from their home states than are companies in the information technology industry. In addition, we find that in both sectors firms experiencing growth are more likely to depart than are stagnant firms.

We also examine the effect of state government innovation programs targeted towards retaining entrepreneurial firms on their likelihood to remain within the state. We apply a competing risks model to compare the hazard of relocation before and after a major program launch, and find a consistent and significant decrease in the relocation hazard for young firms. These results suggest that state initiatives do bolster the retention of entrepreneurial firms, with effects becoming more pronounced over time. On the other hand, we fail to discern a significant decrease in the relocation hazard for growing firms in both short and long event windows. The evidence implies that overcoming a resources gap can be a major consideration faced by science and technology startup companies when they decide to leave their initial founding location, but also that public initiatives may have heterogeneous impact on retaining these firms. Lastly, we restrict attention to the subset of programs that target firms in the life sciences, and apply a difference–in–differences framework to compare the extent to which relocations in targeted versus non–targeted sectors are affected by the existence of a state innovation program. The results provide consistent evidence that such programs reduce the likelihood of entrepreneurial firm relocations more dramatically within the sector targeted by an innovation program. Similar to our earlier finding, our results on the program effects suggest that improving resource availability at the local level can reduce the incentive of entrepreneurial firms to move away.

The Great Lakes region provides a useful context to investigate the extent to which entrepreneurial firms relocate from their home states.[1] Entrepreneurial ideas and human capital in the life sciences and information technology areas—universities, research institutions and incumbent firms—are widely distributed throughout the region. Entrepreneurial resources remain lacking in this area, however (Austin and Affolter-Caine 2006, Samuel 2010). As a result, science and technology startups initially located in this area are more likely to face the tradeoff mentioned above. All else equal, we would expect startups with a higher motivation to pursue growth capital and other entrepreneurial resources to be more likely to leave their home states.

Moreover, the Great Lakes states have pursued "economic gardening" or "grow from within" strategies to support local entrepreneurial activity by launching large innovation programs at the state level. If entrepreneurial firms do move to search for growth capital and other resources and these public initiatives help develop a stronger infrastructure of entrepreneurial resources, the relative disadvantage of staying local should decline over time and reduce the likelihood that promising startup companies will relocate to more resource–rich locations. As Lerner (2009) and others argue, however, there is widespread skepticism of public efforts to support entrepreneurial activity—such programs are notoriously difficult to design and implement. The null hypothesis that state programs will fail to retain entrepreneurial firms is therefore worthy of investigation in itself.

Our study contributes to a growing literature in entrepreneurship on location choices and mobility. Although previous studies have identified institutional, industrial, and firm–level factors that may affect firm location (Alcácer and Chung 2007, Head et al. 1995, Stuart and Sorenson 2003b), much of the prior research focuses on incumbents and less attention has been paid to the proclivity of newly founded science and technology companies to relocate once they have been established. This study also extends prior work by focusing on state innovation programs in a region outside traditional national hubs of entrepreneurial activity

[1] The Great Lakes region is one of the eight distinct regions defined by the Bureau of Economic Analysis (BEA), encompassing the states of Indiana, Illinois, Ohio, Michigan, and Wisconsin.

such as Silicon Valley or the Boston area. By focusing on the Great Lakes region, we provide a more complete picture of how firms develop and migrate across a broader portion of the United States.

This study also contributes to the literature on the effects of institutional and policy changes on sources of friction in entrepreneurial resource markets (Aghion et al. 2007, Kerr and Nanda 2011). Within this stream of research, numerous institutional reforms and policy initiatives have been examined, including the effects of non–compete contract enforcement (Marx et al. 2009, Samila et al. 2011), banking deregulation (Kerr and Nanda 2009, 2010), and intellectual property reforms (Cockburn and MacGarvie 2009, Hall and Ziedonis 2001, Png 2014). However, systematic evidence on state innovation programs aimed at facilitating the development of entrepreneurial resource markets remains lacking (Chatterji et al. 2013, Lerner 2009). While prior studies have shown how institutional and policy reforms affect the decisions of entrepreneurs to start companies (Aldrich and Fiol 1994, Eesley 2011, Eisenhardt and Schoonhoven 1990), little is known about the effect of such reforms on firm geographic mobility.

The reminder of this paper is organized as follows. Section 2 reviews the background and literature related to the geographic location and mobility of entrepreneurial firms. Section 3 describes the context and our empirical approach. Section 4 reports descriptive statistics and regression results. Section 5 summarizes the results, addresses limitations, and discusses opportunities for future research.

2 Background and Related Literature

2.1 "Regional Embeddedness" and Entrepreneurial Firm Mobility

Entrepreneurship has a surprisingly local flavor in that entrepreneurs tend to disproportionately found firms in the cities and states in which they currently reside (Chatterji et al. 2013). Coining the term "regional embeddedness," (Dahl and Sorenson 2012) argue that entrepreneurs tend to start their companies in their home regions where they have richer endowments and could access to resources that would be difficult for an outsider. For example, university spinoffs usually locate near their research facilities, and spin–out firms often take root near their parent companies (Klepper and Sleeper 2005, Saxenian 1996).

This embeddedness stems from multiple factors, including preferences by entrepreneurs to live near family and friends (Dahl and Sorenson 2012), opportunity identification with better access to established social capital and research facilities (Kalnins et al. 2006, Michelacci and Silva 2011), and the avoidance of relocation costs. Figueiredo et al. (2002) quantify such a "home bias," finding that entrepreneurs are more willing to accept over three times higher labor costs to compete in their resident areas of business. Dahl and Sorenson (2012) provide corroborating evidence that entrepreneurs tend to locate in regions in which they have deep roots. Other studies further document that such firms benefit from close proximity to home research institutes and universities that can provide important intellectual human capital and knowledge spillovers (Audretsch et al. 2005, Zucker et al. 1998). Overall, this strand of research shows that individuals start companies in the location where they have formed social and business networks and have access to resources (Feldman and Francis 2004).

Existing research yields insight into how entrepreneurs select the initial location of their companies, yet less is known about the extent to which entrepreneurial firms change their locations over time. Although a number of studies have explored firms' location choices to maximize agglomeration benefits and minimize competition costs (Chung and Alcácer 2002) and to access factor pools (Alcacer and Chung 2014), many of these studies rely on cross-sectional data, assessing location choices at a specific time point. As such, they are unable to inform entrepreneurial firm mobility in a more dynamic way.

Moreover, our understanding of entrepreneurial firms' geographic locations when factor pools are not clustered in one place is incomplete. In a classic framework, Marshall (1896) identifies three factors that may entice firms to locate in proximity—labor market pooling, the presence of specialized suppliers, and knowledge spillovers. Recent studies extend Marshall's work to the field of entrepreneurship and have identified a number of specific factors affecting the location decisions of new ventures, such as the presence of small suppliers, an abundant pool of workers (e.g., Glaeser and Kerr, 2009), funding opportunities (Chen et al. 2010) or social and professional networks (Stuart and Sorenson 2003a). Since factor pools are not always clustered in one place, the firm may find it difficult to secure important factors in their initial location and the tension between "staying local" and "moving away" will be more pronounced as time goes by.

2.2 "Staying Home" vs. Moving Away

While entrepreneurs find initial benefits from locating in their home states, they may subsequently face strong pressure to relocate as they seek to build their companies and commercialize their products. Stuart and Sorenson (2003a) argue that the local conditions that promote the initial establishment of new companies can differ substantially from those needed for the successful expansion and development of those companies. For example, although three inputs often critical for science and technology startup companies—intellectual property, human and financial capital—in principle can move freely, obtaining or leveraging these resources can be difficult for a startup company, thus providing an incentive to relocate. (Chen et al. 2010, Porter and Stern 2001).

The past few decades have witnessed increased activism among state governments aiming to transform entrepreneurial talent and resources into high–growth companies that remain in the state, therefore diversifying the employment and tax base. Although such public interventions are often justified by the theoretical arguments of mitigating market frictions, often their more direct aim is to create jobs within state borders. To achieve this goal and to stimulate the longer–term development of innovative clusters, state governments strive to retain local companies with high growth potential. A related concern is one of "brain drain," the loss of valuable human capital to other states and regions. To achieve these objectives, state initiatives use public funding in various ways. For example, they may provide funding directly to for–profit companies to help them overcome liquidity constraint and bridge the "valley of death,"[2] or to research institutions to support research in leading technology areas and facilitate the technology transfer process. They may also allocate funding to establish intermediary organizations (e.g., catalytic enterprises or incubators), or establish a "fund of funds" program or tax credit program to encourage venture capital investment in the private sector.

If state governments realize these policy objectives and improve the local infrastructure of resources required to form and build new science and technology companies (often through programs such as managerial training; subsidized or easier access to incubators, plants, investors, or other startups), they may create an environment more hospitable toward new science and technology companies. In turn, the relative disadvantage of these locales relative to more established hubs of entrepreneurial activity could be reduced. If true, state innovation initiatives should increase the baseline propensities of startup companies to "stay local," thus accomplishing the stated policy objectives. Not all firms will benefit from these initiatives equally, nor uniformly value the trade–off between staying in their initial location and moving, however. We therefore explore the effect of state–level innovation initiatives on the propensity of different types of firms to forego relocation.

3 Methodology

3.1 Empirical Context

Our study of relocation of technology–based startups examines life sciences and information technology (IT) startups initially incorporated in a Great Lakes state between 1990 and 2009. As Hall and Lerner (2010) discuss, biomedical and IT startups typically require significant external resources from financiers and corporate partners to commercialize their products. However, beyond this similarity, the sectors differ in ways that are particularly

[2]Zhao and Ziedonis (2015) provide a detailed example of such a mechanism in the state of Michigan.

useful in the context of this study. First, the external resources required to commercialize a new drug or complex medical device tend to be an order of magnitude larger than those typically required for the commercialization of IT products. Unlike most IT companies, biomedical firms must obtain regulatory approval prior to the first sale of their products. The cost and complexity of that process, which averages $800 million to $1.2 billion for a new drug and $24 million to $94 million for complex medical devices (Adams and Brantner 2010, DiMasi et al. 2003), leads many biomedical startups to seek expertise and capital from industry incumbents during the product approval process (Hess and Rothaermel 2011, Pisano 1990).

Several state initiatives within the Great Lakes region explicitly target the life sciences sector. In these states, therefore, we would expect that targeted public initiatives would be expected to have more pronounced effects on innovation–oriented life sciences companies than on IT companies.

The Great Lakes region represents represents a good context to examine relocation as the region possesses a strong research, innovation, and talent cultivation infrastructure but economically challenging conditions. Specifically, repositories of human capital and entrepreneurial ideas in the life sciences and information technology areas—universities, research institutions and incumbent firms—are widely distributed throughout the Great Lakes region (Austin and Affolter-Caine 2006)). Nonetheless, Samuel (2010) provides evidence from both statistical analysis and interviews that venture investment funds in this region are presently not large enough to meet later–stage financing requirements for such firms. Austin and Affolter-Caine (2006) similarly assert that a lagging entrepreneurial ecosystem is a factor contributing to regional talent outmigration.

The region also represents a useful source for study due to the active development of innovation programs in these states. As described in the data section, four out of the five states launched at least one program with a budget of more than $1 billion during the sample period. In contrast with policies aimed at attracting large firms to relocate to the state (i.e., "smoke–stack chasing"), these programs focus more on "economic gardening," or the development of services and resources to fund and develop new companies, particularly those in science and technology–related sectors (Plosila 2004).

3.2 Data and Sample

To identify our sample of startups, we rely on the National Establishment Time Series (NETS) dataset, which is based on Dun and Bradstreet (D&B) data that tracks firm locations as well as location changes. The data are constructed by taking annual snapshots of Dun and Bradstreet records every January since 1990. For every establishment identified, D&B assigns a unique "DUNS" number as a means of tracking the establishment. The original data is recorded at the establishment level. However, it also provides detailed annual information regarding the hierarchy between the focal establishment and its headquarters.

To determine the geographic location of each firm, we use the annual six–digit zip code provided for each startup. The NETS data typically include a forwarding address or continuing telephone number or email address that allows D&B to identify whether a firm has moved locations or expanded. An establishment that cannot be contacted at the previous year's address or telephone number will be moved to the "out of business or inactive" file and before any potential new establishment can be given a new DUNS number, it will be checked against the file to see if there is any indication of a movement. When D&B finds evidence that establishment has existed elsewhere, it retains the original DUNS number but reports the new address and the year it changed (Neumark and Zhang 2007).

Our sample is restricted to innovation–oriented, or "technology–based" startups, since such firms are more likely to require significant external resources for commercialization and expansion relative to their less innovation–intensive counterparts. Technology companies are defined as those "engaged in the design, development, and introduction of new products and/or innovative manufacturing processes through the systematic application of scientific and technology knowledge" (Office of Technology Assessment, 1982). The Census Bureau classifies exports and imports that embody new or leading–edge technologies, and the Bureau of Labor Statistics assigns products in technology categories to four–digit NAICS industries that produce them (Hecker 2005). Based on these NAICS codes, we compile a sample of life sciences and IT firms in five industry subsectors: Biopharmaceutical, Medical Devices, Computers, Software, and Computer System Design.[3]

To identify state innovation programs we integrate information from multiple sources, including Berglund and Coburn (1995),[4] the State Science and Technology Institute (SSTI) archives, and the respective state government economic development websites to obtain innovation programs during the study period in the Great Lakes region. The existence of each program is verified by searching Battelle/Bio State Bioscience Initiatives reports, Google archives, and Factiva. This second step allows us to eliminate programs that have been announced but not implemented. We then examine descriptions, program reports, and press releases to identify the relevant characteristics of each program. This information includes program starting year, ending year (if any), and total budget commitment. Note that we collect information on all program types to provide a broad vantage point from which to view the evolution and range of these programs before narrowing focus to those initiatives with a minimum one billion dollar budget. The average size of these major state innovation programs is $1.6 billion, while the combined budget for the remaining within–state programs focusing on innovation or entrepreneurial activity is $985 million.

Table 1 lists the major state innovation programs with an initial total budget larger than one billion dollars launched between 1990 and 2009 in four of the focal Great Lakes states: Illinois, Indiana, Michigan, and Ohio. Wisconsin does not have a pivotal program; instead,

[3]The specific NAICS codes are as follows: (1) Biopharmaceuticals (NAICS 325411–325414); (2) Medical devices (NAICS 334510, 334516, 334517) (3) Computer and related products (NAICS 3341–3342, 3344–3345 excluding 334516 and 333517); (4) Software (NAICS 5112) and (5) Computer system design (NAICS 5415).

[4]Berglund and Coburn (1995)'s compendium of state and federal cooperative technology programs describes and classifies state programs and provides comprehensive information about state innovation programs launched before 1995. Building on that seminal effort, SSTI provides a wealth of information accessible through the SSTI archives, a central digital repository of press releases and news reports about state programs (Feldman et al. 2013).

it has numerous programs housed in various units of the Department of Development.[5] Any targeted sectors of the programs are also list in Table 1.

∗∗∗ Table 1 Here ∗∗∗

During the observation period, Illinois, Indiana, and Ohio each launched one major innovation program and Michigan launched two. Of these initiatives, the BioCrossRoads initiative in Indiana and Life Science Corridor program in Michigan each targeted the life sciences sector. In contrast, the other initiatives were non–sector–specific, emphasizing a broader array of sectors ranging from IT and advanced materials to alternative energy and the life sciences. Of the two initiatives launched in Michigan, we restrict attention to the first Life Science Corridor program. Since Michigan's second program, the 21st Century Jobs Fund, was formed in the immediate aftermath of the first large–scale program, we are unable to observe a clean pre–program trend for the 21st Century Jobs Fund.

3.3 Variable Definitions

Dependent Variable:

The dependent variable, $RELOCATION$, equals one when a focal firm initially incorporated in one of the five Great Lakes States relocates to another state and zero otherwise. Relocation is defined broadly to include not only the firm's departure from the state as a standalone company, but also business relocation driven by mergers and acquisitions (M&A). More specifically, relocation is set to one if either (a) a startup moves out of its home state, or (b) a startup changes its headquarters (typically due to M&A) to another state and its employment count declines after the change. The latter restriction (of an employment decrease post-headquarter move) helps us distinguish between corporate takeovers where the startup and its employees are left "intact" within the state and ones where business operations are

[5] More specifically, Wisconsin maintained 152 state economic development programs from 2001 to 2004. As of 2011, more than 25 separate business development programs were administered by the Division of Business Development.

redirected to the headquarter state, a more worrisome outcome for state policy–makers. The unit of analysis is a firm–state–year. A firm is at risk of relocation after it is founded in a focal state. Once a startup relocates out of its home state, it exits the analysis.

The observation period, 1990–2010, spans the launch of landmark programs within the region. Sample firms are founded after 1990 (inclusive) and right censored at year 2010. Firm closure before 2010 is treated as a competing–risk event that prevents the focal firm from experiencing a relocation event. Details regarding the estimation method are discussed in the next section.

Overall, the sample includes 44,513 firms and five states over a 20–year time period (1990–2010). Of these firms, 1,080 relocate to another state during the sample period, typically as standalone companies (96.8% of the moves) but sometimes as part of a merger or acquisition (3.2%). Within the subsample of firms in the life sciences sector, 91.7% of the relocations are classified as moves by standalone companies; within the subsample of firms in the information technology sector, 97% of the relocations are classified as moves by standalone companies. The average relocation ages for life sciences and information technology companies are 5.8 and 5.6 years old, respectively. Table 2 reports the number of information technology and life sciences firms in the sample from each of the five states.

∗∗∗ Table 2 Here ∗∗∗

3.4 Key Independent Variables

We are interested in the effects of the following independent variables on the startup's relocation decision:

LIFE SCIENCES: This variable represents a time–invariant industry sector indicator. This indicator takes a value of one if the focal firm is from the life sciences sector and zero if the company is from the information technology sector. This sector–level variable captures any heterogeneity between life sciences and IT firms in the average resource needs for commercialization, and thus enables us to identify startups in sectors targeted by state innovation programs.

GROWING: Growing firms are expected to have greater needs for external resources than firms not experiencing growth. To test whether growing companies are more likely to relocate, we define the variable *GROWING* as a time–invariant indicator that equals one if the number of the focal firm's current (or most recent) employees is more than its initial employment number and zero if it is the same or lower.

YOUNG: State innovation programs are designed to aid entrepreneurs in their early stage of development by providing resources to conduct applied R&D, transform innovations to the commercialization stage, and grow their companies. To test whether state innovation programs have more pronounced effects on young firms, we define *YOUNG* as a time–invariant indicator equal to one if the focal firm is founded within three years before the major program launch or when the program is active in its home state, and zero otherwise. For example, if a program is launched in 1999, any firm incorporated after 1996 would be considered to be young.

PROGRAM WINDOW and *POST–PROGRAM*: To test the impact of state innovation programs on the likelihood of entrepreneurial–firm relocation, we construct two program indicator variables. *PROGRAM WINDOW* is a state–year program indicator equal to one for the three (five) years following a major program launch and equal to zero for the three (five) years preceding the program launch. *PROGRAM WINDOW* therefore provides a 6 (10)–year program event window within which to compare the hazard rates of relocation before and after a program launch. As an alternative measure, *POST–PROGRAM*, observed at the state–year level, is set as equal to one for the time period after the program launch and equal to zero for the time period before the program launch. *POST–PROGRAM* therefore provides a longer pre– and post–program estimation period for firms at the state level than does *PROGRAM WINDOW*.

3.5 Control Variables:

A number of factors at the firm, industry, or macroeconomic level could influence the decision by an entrepreneur to move to another state. At the firm level, we control for the size of the focal company as measured by the number of employees in a specific year (thus size is a time–variant variable). At the industry and macroeconomic levels, we calculate the Herfindahl–Hirschman Index (HHI), industry growth rate, and state real GDP growth rate for each state. For the Herfindahl–Hirschman Index we measure the market concentration in each state. We first aggregate the establishment–level data from the NETS dataset to the industry subsector level for each state and then calculate the time–variant HHI. We compute the local industry subsector growth rate for each state as the percentage change of total sales by industry subsector for each state over time. At the macroeconomic level, we also compute the state real GDP growth as a control variable. The state GDP growth rate is calculated as the percentage of real state GDP, using data from the Bureau of Economic Analysis (BEA). All industry and macroeconomic–level variables are lagged one year to allow time for relocation.

Table 3 reports mean values and the results of difference in means tests for characteristics of firms in information technology and life sciences within the sample. For firms that eventually relocate by the end of the sample period, there is little difference between these industries in the time of relocation (5.56 years for IT firms and 5.81 years for life sciences firms). Life science firms, however, on average enter the sample with a significantly greater number of employees and a significantly higher level of sales than do IT firms (14.86 vs. 4.62 and $2,076,760 vs. $517,585, respectively.)

∗∗∗ Table 3 Here ∗∗∗

Table 4 reports the summary statistics for the firm–year observations of the sample. All covariates pass the variance inflation factor (VIF) test for multicollinearity. The mean value of the growing firm indicator *GROWING* shows that only 23% of the firms have more employees than their initial number when founded.

∗∗∗ Table 4 Here ∗∗∗

3.6 Estimation Approach:

To obtain baseline statistics on the extent of relocation for the firms in the sample, we first track the relocation patterns of a cohort of companies established at the beginning of the observation period (1990–1994) and investigate whether the relocation likelihood differs by the type of company within the sample. We then use a competing–risks regression model to examine the relocation hazard across different types of firms.

Survival analysis has long been used to examine predictors of the time to an outcome or event. A Cox proportional hazard model is often employed since it does not require a parametric function form for the baseline hazard, or short–term event rate for subjects that have not yet experienced the event. In the context of this study, however, a firm may experience a competing event (closure) before it experiences the event of interest (relocation). If these events are not independent, treating the firm that experienced the competing event as censored can bias the estimation. Our model thus must take into account that the likelihood that firms experiencing one event to experience the alternative event is zero. To fulfill this requirement, we use the competing risks model proposed by Fine and Gray (1999). This model enables us to assess the effect of covariates on the sub–hazard for both the event of interest and the competing event of failure (Cleves et al. 2010). The competing risks model uses semi–parametric methods to estimate the covariate effects on the cumulative incidence function (CIF). The cumulative incidence function (CIF) measures the probability that the event of interest occurs before a given time. In order to define the CIF, we first define the sub–hazard function for the event of interest as follows:

$$\bar{h}(t) = \frac{lim_{\Delta \to 0} = P\{t \leq T < t + \Delta t,\ \text{event of interest} \mid T > t\ or\ (T \leq t \text{ and other events})\}}{\Delta t} \tag{1}$$

Note that CIF(t) is a function of the sub–hazard only for the event of interest, so if a regression model is defined for $\bar{h}$(t), it can be used to interpret the covariate effects on CIF(t). This leads to the following representation:

$$CIF(t) = 1 - exp\left\{\int_0^t \bar{h}(u)du\right\} \tag{2}$$

The Fine and Gray (1999) model is a direct analog to a Cox regression where the sub–hazard function takes a traditional semi–parametric functional form. In this context, the sub–hazard function estimates the hazard of firm i relocating out of state j in year t using the following functional form:

$$\bar{h}_{ij}(t) = \bar{h}_0(t)\ exp[\beta X_{it} + \gamma Y_{jt}] \tag{3}$$

where $h_{ij}(t)$ is the hazard rate that firm i relocates out of state j in year t conditional on having not done so by year t, while treating firm closure as a competing–risk event.[6] Furthermore, $h_{ij}(t)$ represents an arbitrary baseline hazard function. X_{it} is a vector of firm characteristics and Y_{jt} is a vector of environmental characteristics including state, industry, and macroeconomic–level controls. Robust standard errors, clustered by startup, allow for intra–firm non–independence of observations.

Equation (4) adds a time–invariant life science industry indicator to estimate the difference of relocation patterns between life sciences companies and information technology companies. We also include the indicator *GROWING* to the baseline model to estimate the difference in relocation hazard rates between growing companies and non–growth firms.

[6]The terms "hazard of relocation" and "sub–hazard of relocation," used synonymously, refer to the marginal probability for the event of relocation.

$$\bar{h}_{ij}(t) = \bar{h}_0(t)\ exp[\alpha(\text{LIFE SCIENCE})_i \beta X_{it} + \gamma Y_{jt}] \tag{4}$$

To estimate the major innovation program effect on relocation, we employ two different approaches. First, we use the *PROGRAM WINDOW* Indicator to construct a 6–year (10–year) program event window for Illinois, Indiana, Michigan, and Ohio with billion dollar programs and compare the relocation hazard rates three (five) years before and three (five) years after the program launch. Since their focal programs target only the life sciences industry, the sample includes only life sciences companies from Indiana and Michigan. Since programs in Illinois and Ohio target both life sciences and information technology sectors, the sample includes firms from both industries for these two states. As mentioned above, Wisconsin is not included in the analysis. Equation (5) presents the estimation model.

$$\bar{h}_{ij}(t) = \bar{h}_0(t)\ exp[\alpha(\text{PROGRAM 1})_{jt} + \beta X_{it} + \gamma Y_{jt}] \tag{5}$$

Our second approach is to utilize a difference–in–differences framework to examine relocation differences between life sciences and IT firms in the two states that launched life sciences–oriented programs, Indiana (BioCrossRoads), and Michigan (Life Science Corridor). As shown in model (6), the main coefficient of interest is α, which indicates the program impact on life science companies compared to information technology companies.

$$\begin{aligned} \bar{h}_{ij}(t) = \bar{h}_0(t)\ exp[&\alpha(\text{PROGRAM 2})_{jt} \times \text{LIFE SCIENCE}_i \\ &+ \beta(\text{PROGRAM 2})_{jt} + \text{LIFE SCIENCE}_i + \rho X_{it} + \tau Y_{jt}] \end{aligned} \tag{6}$$

4 Results:

We first estimate how likely life sciences and IT firms are to move from their home states to other locations. We then consider whether this likelihood is affected by industrial sector.

Finally, we investigate our primary question of interest, whether the establishment of a state innovation program affects relocation likelihood.

We begin our investigation by first conducting a non–parametric analysis without controls to estimate the proportion of companies founded in an early cohort that relocated out of their home states by 2010.[7] After establishing the base likelihood of relocation, we use a more rigorous competing–risks regression model to investigate whether life sciences and information technology firms differ in their likelihood of relocation and whether state innovation programs affect that decision.

4.1 Relocation Patterns

Figure 1 presents the proportion of firms established between 1990 and 1994 that chose to relocate by 2010. Conditional on survival until 2010, we find that 4.6% of companies in the sample moved out of their home states. Not surprisingly, this percentage is higher for growing firms, which may have greater incentives to search for additional external resources in a new location. Indeed, the results show that 5.9% of high–growth firms in the sample relocated by 2010.

∗∗∗ Figure 1 Here ∗∗∗

Since life science companies often have higher requirements for external resources for commercialization and company growth than do IT companies, we would expect a higher proportion of life science companies to relocate. After dividing the sample into life science and IT firms, we find that 11.8% of growing life sciences companies relocated, while only 5.6% of growing IT firms departed, consistent with that expectation.

∗∗∗ Figure 2 Here ∗∗∗

In the above analysis, closure and relocation are treated as independent events. However, to estimate the probability of relocation before a certain time, it is more precise to take into

[7]Note that these statistics are conditional on firm survival until the end of our observation period.

account that firm closure may also occur and to treat this possibility as a competing risk. When competing risks exist, we use the cumulative incidence function instead of the normal survival function.

To empirically tests the covariate effects on the hazard rates of entrepreneurial–firm relocation, we use the semi–parametric method of modeling covariate effects on the cumulative incidence function as described in the previous section. Using the full sample of companies, Figure 3 plots the overall cumulative incidence for the event of relocation while treating closure as a competing risk. The overall hazard rate for relocation accumulates to around 3.2% by the end of the analysis time period.

$\ast\ast\ast$ Figure 3 Here $\ast\ast\ast$

Table 5 presents the results from the competing risks analysis. Column (1) shows the baseline results for the difference in relocation probability between the life sciences and information technology samples. Column (2) presents the results adding founding year fixed effects to allow for firms founded in different calendar years to face different hazards. The results in Columns (1) and (2) show that, after controlling for time–variant firm–level, industry–level and macroeconomic–level covariates, life sciences companies have a significantly higher rate of relocation than IT companies. More specifically, over the analysis time period, life science companies experience hazard rate of relocation 235% to 260% of other firms (based on the *LIFE SCIENCE* coefficients in columns 1 and 2 of Table 5).[8]

$\ast\ast\ast$ Table 5 Here $\ast\ast\ast$

This result is depicted graphically in Figure 4, which plots the predicated cumulative incidence of relocation for life sciences and information technology companies.

$\ast\ast\ast$ Figure 4 Here $\ast\ast\ast$

[8]The hazard rate equals e^{β}, for example $e^{(0.854)} = 235\%$.

Similarly, the results in Columns (3) and (4) in Table 5 show the comparative relocation hazards for growing vs. non–growth firms. Growing companies are expected to have higher incentives to move due to their greater need for external resources. The result provided in Column (3) is consistent with this prediction. More specifically, the estimates suggest that growing companies face a 98.2% to 99.1% higher hazard rate of relocation than do non–growth firms based on the coefficients for *GROWING* in columns (3) and (4). Figure 5 graphically depicts the predicted cumulative incidence of relocation for growing versus non–growth firms. These results suggest that companies with more employees in the current year than their initial year have significantly higher relocation rates than firms with the same or fewer current employees.

∗∗∗ Figure 5 Here ∗∗∗

Examining the results for the control variables, the coefficients for firm size are consistently significant at the 1% level, indicating that larger firms are more likely to move out of their home state. In addition, higher state market concentration is significantly associated with a lower likelihood of departure. That is, firms prefer to stay when their local market shows relatively higher concentration. Moreover, the results show that both higher state industry sub–sector growth and higher economic growth is correlated with a lower the likelihood of firm relocation. This result is not surprising; favorable industry and economic conditions provide a more promising environment for a firm to remain.

Overall, the evidence suggests that life sciences startups are more likely to relocate than are new information technology companies, and that growing companies are more likely to relocate than are non–growth firms. We interpret this evidence as consistent with the view that firms that require more external resources (financial/human capital, support services) during the commercialization process are disproportionately more likely to leave the state than firms that do not face such challenges.

4.2 The Effect of State Innovation Programs on Firm Relocation

In this section, we outline the two empirical approaches used to test whether state innovation programs in the focal Great Lakes states reduce relocation likelihood. In the first approach (as shown in Equation (6)), we create two event windows—a 6–year short event window and a 10–year long event window—around the major program launch time. After controlling for other time–variant firm–level, industry–level and macroeconomic–level covariates, we investigate whether the relocation hazard rate changes after program launch.

The results based on this first approach are presented in Table 6. Column 1 of Table 6 shows that after the program launch, firms have a lower hazard rate of relocation (the coefficient for *PROGRAM WINDOW* is negative). The effect is not, however, statistically significant at the conventional statistical level. Column 2 provides evidence that the program has an effect on relocation by firms established within three years before the program launch or when the program is active (young firms). Combining the coefficients for *PROGRAM WINDOW* and the *PROGRAM WINDOW X YOUNG* interaction terms produces a hazard rate of relocation for young firms after the program launch that is 2.4% lower on average than before the launch. Interestingly, the interaction term *PROGRAM WINDOW X GROWING* in column 3 indicates that program effects do not differ for growing and non–growth firms (the coefficient for this interaction term is not significant).

Panel B of Table 6 presents results using a 10–year event window. Overall, these results are similar to those in Panel A. The program effects on firm relocation are more pronounced in this longer period for young firms, however. The coefficients for *PROGRAM WINDOW* and *PROGRAM WINDOW X YOUNG* combine to produce a 16.4% lower hazard rate on average for these firms as a result of the program. This result suggests that the program effects on young firms are more pronounced over a longer time period.

∗∗∗ Table 6 Here ∗∗∗

The above results could be confounded by state level trends that occur simultaneously with the establishment of a state program. For example, unobserved factors affecting the economic environment could influence firms' relocation decisions irrespective of the establishment of a program. To account for this possibility we limit our analysis to the states of Indiana and Michigan, where programs were targeted towards the life sciences sector. This allows us to consider the effect of programs targeted towards one sector, life sciences, on the relocation decisions of both life sciences and IT firms. This approach is depicted in Equation 6 of Section 3.6. Specifically, we analyze the effects of the Indiana and Michigan state innovation programs on firm location decisions within the respective states. Our difference–in–differences framework tests the extent to which the rate of relocation hazard for life sciences companies changes as a result of the targeted program differs from that of information technology companies. The intuition behind this analysis is that if life sciences–oriented programs are effective in retaining high technology firms, the relocation hazard rate should decrease more dramatically in the life sciences versus the information technology sector.

Table 7 presents the results from this second approach. In all three model specifications, the coefficients of the interaction terms are negative and consistently significant. Including industry and macroeconomic control variables yields similar results.

The coefficient for *PROGRAM WINDOW* is positive and significant for all three models in Table 7. This outmigration is even more pronounced for life sciences firms, as *LIFE SCIENCE* is positive and significant in all three models (although the coefficient in model 2 is weakly significant at the 10% level). This is not surprising as states would be most likely to implement innovation programs at the time that they are suffering the highest migration from the state. More importantly, the interaction term *PROGRAM WINDOW X LIFE SCIENCE* is negative and significant in models 1–3 (albeit at the 10% level in models 2–3). This suggests that the hazard rate for outmigration of life sciences firms is lower relative to IT firms following the establishment of programs targeted towards the life sciences sector.

$***$ Table 7 Here $***$

Overall, these findings suggest that the probability that new science and technology companies from the Great Lakes states will relocate decreases following the launch of a major state innovation program. Furthermore, we find that this effect is more pronounced for young firms and for firms targeted by such a program.

5 Discussion and Conclusion

In an effort to "set a better table" for new innovation–oriented companies, many state governments, jointly with other organizations, have poured billions of public monies toward infrastructure development and support to encourage entrepreneurs (Lerner 2009). Given the well–documented failures of policymakers to boost entrepreneurship (Lerner 2009) and the magnitude of this financial commitment, there are valid reasons to be skeptical about the extent to which such policy initiatives can shape firm decisions and thus a state's economic development.

Based on nonparametric and semi–parametric analyses of a sample of life sciences and IT startups established in the Great Lakes region between 1990 and 2010, we find evidence that high technology companies in the life sciences sector are more likely to relocate out of their home states compared to those in the information technology sector during the same observation period. Among these startups, firms experiencing growth are disproportionately more likely to leave their originating state. These findings are consistent with the view that relocation is in part driven by the need to secure access to external resources required for commercialization and expansion. We also find that this proclivity of science and technology startups to relocate to other states declines significantly in the wake of major program launches by state governments in the Great Lakes region, particularly for young firms and for those firms in sectors directly targeted by the program.

In combination, these findings suggest that high technology companies initially located in a region with a good innovation infrastructure but a relatively weak entrepreneurial ecosystem may decide to relocate. To the extent that an entrepreneurial resources market is efficient, capital, talent and other related services can be allocated effectively to startup companies at the right place and right time, thus lessening the incentive to relocate to access such resources. The findings in this study consequently imply the existence of market frictions for entrepreneurial resources that may lead to relocation to overcome such frictions. Indeed, even after controlling for state–level market and industry sector conditions, our findings suggest that firms with higher requirements for external resources for commercialization and expansion are still more likely to relocate.

State innovation programs are often justified by market friction arguments. If such programs can improve the local entrepreneurial ecosystem, then there should be a lower hazard of relocation. Our findings support this argument. On the other hand, our results also show that these programs do not have a strong impact in retaining growing firms, which suggests that the firms that remain may be those with less promising growth expectations. From a public policy perspective, this selection process may have a long–term consequence that contradicts the main objective of these public initiatives.

Although an initial step towards understanding the impact of state innovation programs on firm relocation decisions, this study has several limitations. First, we treat program launches across states as equivalent—thus ignoring factors that may make individual programs more or less effective regarding relocation. We also focus on the home state without considering the state of relocation destination. One consequence of this omission is that we ignore any policies by the recipient state that may act to induce relocation. We are currently investigating where relocating firms move; as such we may be able to gain a more complete picture of the reasons for firm outmigration. We also do not yet fully explore the performance of companies that are more likely to relocate. For example, future work could further investigate factors affecting relocation choices by companies with high growth potential.

The economic success of regional high–technology clusters such as the San Francisco Bay Area, Boston, San Diego, and the Research Triangle in North Carolina has spurred policy makers in other regions to pursue economic policies aimed toward forming their own innovation–based clusters. Local and state–based policies such as tax credits, subsidies, and other incentives intended to foster entrepreneurship and subsequent economic growth have been widely studied. Less is known, however, on the effect of these policies on the relocation by entrepreneurs to other regions, subsequent to their formation. Preliminary results of this study suggest that while state innovation programs may positively affect the retention of entrepreneurial firms, firms exhibiting the highest rates of growth may still be an elusive target.

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Table 1: Major State Innovation Programs, 1990–2009

State	Program	Year Started	Year Ended/ Inactive	Initial Budget Announced/ Committed	Major Technology Target Areas
Illinois	IL VentureTECH	2000	2005	$1,900M	Life Sciences, Information Technology, Advanced Physics
Indiana	BioCrossRoads (Central Indiana Life Sciences Initiative)	2002	Ongoing	$1,500M	Life Sciences
Michigan	Michigan Life Science Corridor (Michigan Technology Tri–Corridor after 2004)	1999	2005	$1,000M	Life Sciences (Extended to Advanced Manufacturing, Homeland Security after 2004)
	The 21st Century Jobs Fund	2006	Ongoing	$2,000M	Life Sciences, Advanced Manufacturing, Homeland Security, Defense Alternative Energy
Ohio	Ohio Third Frontier	2002	Ongoing	$1,600M	Life Sciences, Information Technology, and Others

Table 2: Distribution of Information Technology and Life Sciences Firms by State

State	Information Technology	Life Sciences
Illinois	14,601	386
Indiana	4,240	174
Michigan	10,231	283
Ohio	9,688	318
Total	43,172	1,341

Table 3: Firm Level Descriptive Statistics by Industry

Variable	Information Technology	Life Sciences	Difference in Means Test (t–statistic)
Initial No. of Employees	4.62	14.86	7.77***
Initial Sales	$517,585	$2,076,760	7.46***
Age at Relocation (Conditional on Relocation)	5.56	5.81	0.376

* $p>0.10$, ** $p>0.05$, *** $p>0.001$

Table 4: Summary Statistics for Competing Risks Models: Unit of Analysis = Firm–Year

	Variables	Obs.	Mean	S. D.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	*GROWING*	292936	0.23	0.42	1									
(2)	*LIFE SCIENCES*	292936	0.03	0.16	0.017	1								
(3)	*YOUNG*	292936	0.45	0.50	-0.018	0.007	1							
(4)	Employment	292936	6.47	41.39	0.078	0.044	-0.026	1						
(5)	Local Market Concentration (%)	292936	2.33	3.89	0.006	0.720	-0.037	0.038	1					
(6)	Local Industry Subsector Growth (%)	292936	4.81	11.01	0.003	- 0.028	-0.241	-0.004	0.038	1				
(7)	State Real GDP Growth (%)	292936	1.78	2.43	0.017	- 0.026	-0.297	0.000	0.017	0.316	1			
(8)	*PROGRAM WINDOW* (10–year)	168631	0.55	0.50	-0.021	0.046	0.457	-0.003	-0.113	-0.509	-0.519	1		
(9)	*PROGRAM WINDOW* (6–year)	66243	0.53	0.50	-0.010	0.016	0.181	-0.010	-0.101	-0.696	-0.288	-0.870	1	
(10)	*POST–PROGRAM*	95896	0.63	0.48	-0.020	0.029	0.466	-0.002	0.074	-0.583	-0.483	1.000	1.000	1

Table 5: Competing Risks Regressions: Relocation vs. Closure

Variables	(1)	(2)	(3)	(4)
Key Independent Variables				
LIFE SCIENCES	0.854*** (0.227)	0.957*** (0.232)		
GROWING			0.689*** (0.067)	0.638*** (0.069)
Control Variables				
Firm Size (# of employees)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
State Market Concentration (%)	-0.048*** (0.013)	-0.053*** (0.013)	-0.029** (0.013)	-0.033** (0.014)
State Industry Subsector Growth (%)	-0.025*** (0.003)	-0.031*** (0.003)	-0.025*** (0.003)	-0.031*** (0.003)
State Real GDP Growth	-0.092*** (0.014)	-0.13*** (0.015)	-0.093*** (0.014)	-01.31*** (0.015)
State Dummies	Yes	Yes	Yes	Yes
Industry Subsector Dummies	No	No	Yes	Yes
Founding Year Dummies	No	Yes	No	Yes
No. of Observations	292,936	292,936	292,936	292,936
No. of Firms	44,513	44,513	44,513	44,513
Log–Likelihood	-11186	-11154	-11133	-11109

Notes:
*** $p<0.01$ ** $p<0.05$ * $p<0.10$
Robust standard errors in parentheses.
Competing risks models with time–variant covariates.
The event of interest is relocation and the competing risk is firm closure.

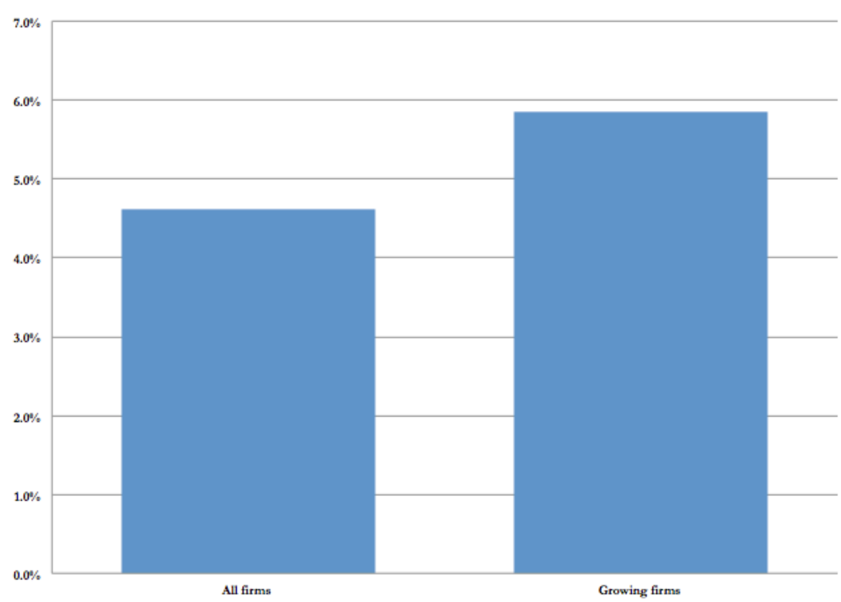

Figure 1: Proportions of Firms Formed in 1990–1994 and Relocated to Another State by 2010

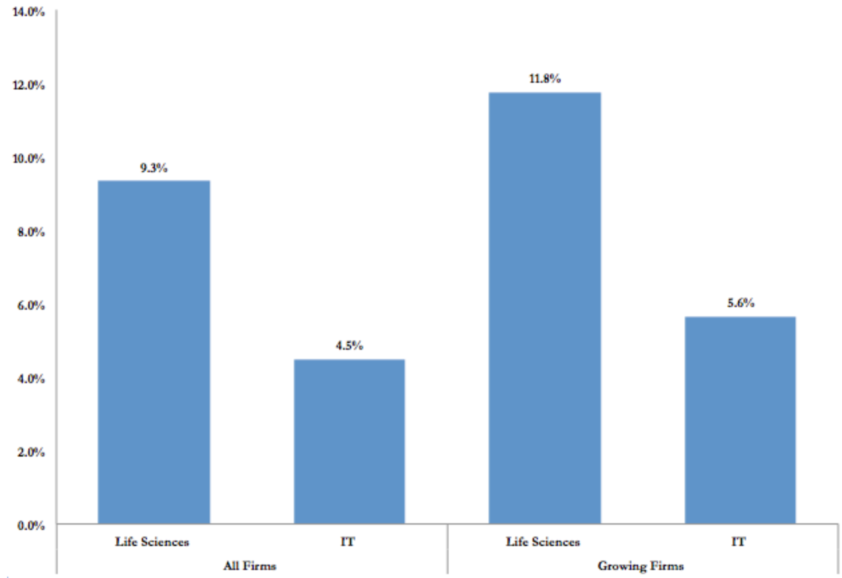

Figure 2: Proportions of Firms Formed in 1990–1994 and Relocated to Another State by 2010

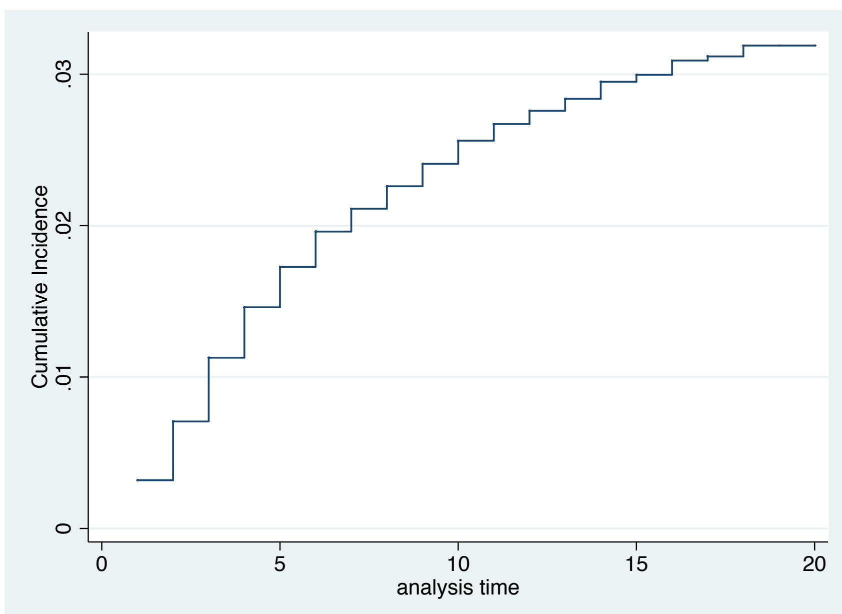

Figure 3: Cumulative Incidence of Relocation: Full Sample

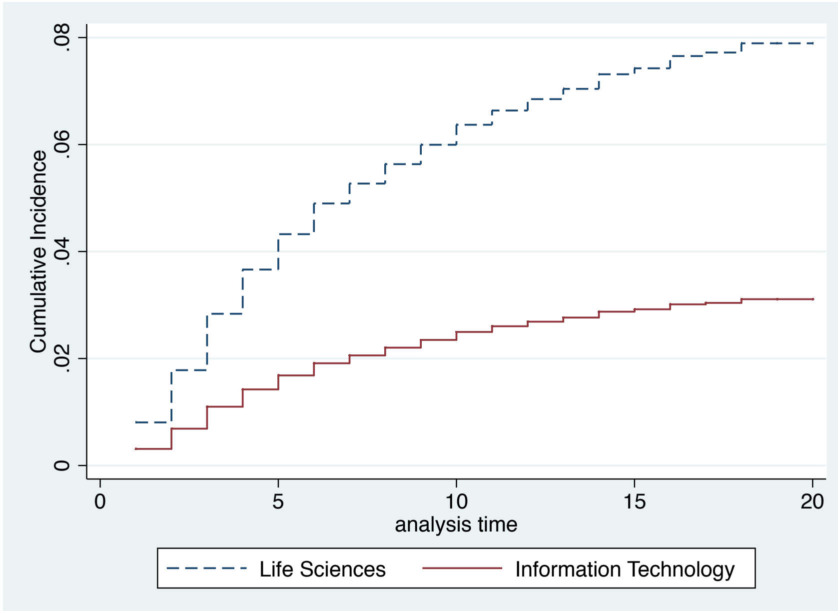

Figure 4: Cumulative Incidence of Relocation: Life Sciences vs. IT Firms

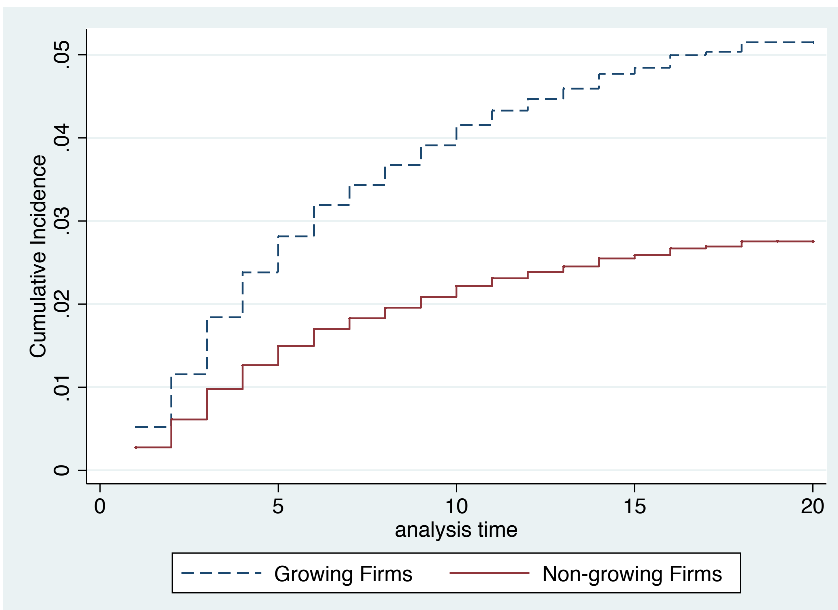

Figure 5: Cumulative Incidence of Relocation: Growing vs. Non–Growing Firms

Table 6: The Effect of State Innovation Programs on Relocation

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: 6–Year Pgm. Event Window			Panel B: 10–Year Pgm. Event Window		
Key Independent Variables						
PROGRAM WINDOW	-0.044 (0.182)	0.444* (0.250)	-0.140 (0.194)	-0.132 (0.161)	0.649*** (0.225)	-0.186 (0.176)
YOUNG		-0.623*** (0.185)			-0.295* (0.158)	
GROWING			0.295 (0.199)			0.590*** (0.169)
PROGRAM WINDOW × *YOUNG*		-0.468* (0.251)			-0.828*** (0.223)	
PROGRAM WINDOW × *GROWING*			0.403 (0.250)			0.252 (0.211)
Control Variables						
Firm Size (# of employees in 10s)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
State Market Concentration (%)	-0.060 (0.046)	-0.058 (0.045)	-0.062 (0.046)	0.063 (0.040)	0.070 (0.043)	0.064 (0.040)
State Industry Subsection Growth (%)	-0.016** (0.007)	-0.016** (0.007)	-0.015** (0.007)	-0.021*** (0.006)	-0.019*** (0.006)	-0.020*** (0.006)
State Real GDP Growth (%)	-0.100*** (0.033)	-0.131*** (0.033)	-0.120*** (0.033)	-0.119*** (0.030)	-0.149*** (0.030)	-0.123*** (0.030)
State Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry Subsection Dummies	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	66,243	66,243	66,243	107,344	107,344	107,344
No. of Firms	16,849	16,849	16,849	20,515	20,515	20,515
Log Likelihood	-3031	-3017	-3020	-4301	-4279	-4276

Notes:
*** p<0.01 ** p<0.05 * p<0.10
Robust standard errors in parentheses.
PROGRAM WINDOW is a time–variant variable equal to one for the three (five) years after the program launch and equal to zero for the three (five) years before the program launch.
All regressions are estimated using a competing–risks model with time–variant covariates.
The event of interest is relocation and the competing–risk event is firm closure.

Table 7: Difference–in–Differences Estimates of State Life Sciences Innovation Program Effects on Relocation (Indiana and Michigan)

Variables	(1)	(2)	(3)
Key Independent Variables			
POST–PROGRAM	0.979***	0.984***	0.778***
	(0.122)	(0.122)	(0.172)
LIFE SCIENCES	1.054**	0.848*	1.450**
	(0.464)	(0.484)	(0.648)
POST–PROGRAM	-1.296**	-1.093*	-1.076*
× *LIFE SCIENCES*	(0.605)	(0.621)	(0.619)
Control Variables			
Firm Size		0.001***	0.001***
		(0.000)	(0.000)
State Market Concentration (%)			-0.027
			(0.017)
State Industry Subsector Growth (%)			-0.011
			(0.007)
State Real GDP Growth			-0.037
			(0.023)
State Dummies	Yes	Yes	Yes
No. of Observations	95,896	95,896	95,896
No. of Firms	14,928	14,928	14,928
Log–Likelihood	-3293	-3289	-3284

Notes:
*** $p<0.01$ ** $p<0.05$ * $p<0.10$
Robust standard errors in parentheses.
POST–PROGRAM is a time–variant variable equal to one for the years after the program launch and equal to zero for the years before the program launch.
All regressions are estimated using a competing–risks model with time–variant covariates.
The event of interest is relocation and the competing–risk event is firm closure.