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**Startup Survival and a Balanced Burn Rate**

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**Abstract**

How much to spend is a key managerial decision for entrepreneurs. Arguments favoring lean startups rely on the burden of rapid growth, reduced monitoring costs or the inefficient use of cash. Arguments favoring high “burn rates” rely on the early creation of economies of scale and complementary assets; and the motivation benefits of efficiency wages and experimentation. We argue that survival benefits of spending should be balanced against the potential costs and empirically show that there is a U-shaped relationship between burn rate and the probability of failure. In addition, drawing on the literature of entrepreneurial human capital, we find that an entrepreneur’s education and confidence about possessing a competitive advantage over competitors have a positive relationship with balanced spending leading to lower failure rates.

# Startup Survival and a Balanced “Burn Rate”

## **Abstract**

How much to spend is a key managerial decision for entrepreneurs. Arguments favoring lean startups rely on the burden of rapid growth, reduced monitoring costs or the inefficient use of cash. Arguments favoring high “burn rates” rely on the early creation of economies of scale and complementary assets; and the motivation benefits of efficiency wages and experimentation. We argue that survival benefits of spending should be balanced against the potential costs and empirically show that there is a U-shaped relationship between burn rate and the probability of failure. In addition, drawing on the literature of entrepreneurial human capital, we find that an entrepreneur’s education and confidence about possessing a competitive advantage over competitors have a positive relationship with balanced spending leading to lower failure rates.

Keywords: spending per employee; burn rate; survival; overconfidence; startup; managerial capital.

# 1 Introduction

Entrepreneurs can strategically control the expenditures of their firms to achieve different goals. Although spending per employee (or “burn rate”) is a popular concept among practitioners<sup>1</sup> and a critical decision for entrepreneurs, we know little about its actual relationship to start up firms’ performance. On the one hand, small firms facing good prospects (e.g., large user base, growing revenues and market share, and specific and complementary assets) may need to increase their spending to survive and ultimately sustain a competitive advantage; but on the other hand, firms may fall into inefficiency traps or exit due to overspending. The goal of this paper is to analyze the relationship between de novo entrants’ burn rates and their survival, as well as identify the determinants of the burn rate.

There is little consensus among academics (and practitioners) as to the best approach entrepreneurs should pursue with regards to their spending strategy. It has been recognized by strategy scholars that small firms suffer from “the liability of smallness.” Small firms face difficulties raising capital or recruiting and training high skilled employees (Aldrich and Auster 1986, Baum and Locke 2004, Pe’er et al. 2014). To increase the chances of survival, the theory argues, firms should pursue aggressive investment tactics to attain earlier economies of scale, access complementary assets, signal a deep pool of resources or encourage risk-taking and experimentation (Fan 2010, Mata and Portugal 2002, MacMillan and Day 1987, Teece 1986, Cooper et al. 1986, March 1981). Aggressive expenditures by de novo entrants, however, may create inefficiencies. As documented by several case studies (Marmer et al. 2011) and advocated by the “lean startup” approach (Blank 2013), firms often overspend and grow inefficiently and prematurely. The process of discovery of new opportunities to profit from is far from trivial, and can be extremely costly and potentially lead to failure if not done properly (Shane 2000). Firms trying to scale up quickly may run out of cash by hiring the wrong people or purchasing useless assets (Arora and Nandkumar 2011). From a resource-based perspective, small firms with few employees may not need to incur high monitoring costs and powerful short-run incentives to motivate employees (Brown and Medoff 1989, Bulow et al. 1986). From a strategic stand point, increased expenses can become a handicap because they may reduce the ability and incentive to respond aggressively to competitors

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<sup>1</sup>See, e.g., <http://www.inc.com/jessica-stillman/how-to-tell-if-your-startup-s-burn-rate-is-ok.html> and <http://techcrunch.com/2015/04/05/burn-rate-doesnt-matter/>

(Fudenberg and Tirole 1984), especially in highly dynamic industries (Lieberman and Montgomery 1988). Although the amounts of initial funding to raise, how much to spend on product launches and how to allocate other funds are key strategic decisions, we know little about whether there is a statistical relationship between expenditure per employee and survival, and if so, what the shape and direction of this relationship is. Our baseline hypothesis is that spending per employee should exhibit a U-shaped relationship with the probability of failure. We argue firms on average enjoy increased survival benefits from higher expenditures per employee up to an “optimal” level. Beyond this point firms may increasingly use resources in a way that threatens survival.

To test this hypothesis, we estimate a model of *de novo* entrants survival as a function of spending per employee, other firm characteristics and strategic features of the environment. We follow the recent literature in that we use firm survival as our dependent variable because, among other reasons, it is easier to measure and harder to manipulate than other indicators of performance such as sales or profits (Robb and Watson (2012)). Apart from being a key strategic choice of the entrepreneur, spending per employee is also widely used by professional investors as it is relatively easy to collect and monitor. Our main data source is the Kauffman Firm Survey (KFS). The KFS collected firm-level information (including expenditures and number of employees) from a representative sample of startups founded in 2004 and followed them up until 2011 (inclusive). We augment this information with the US Census County Business Patterns (CBP) data on number of firms, employment and payroll distribution by MSA and by state and with the US Bureau of Labor Statistics Occupational Employment Statistics (OES) data for statistics about specific occupations in different industries.

The second question we address in this paper is whether entrepreneur’s characteristics used in the literature are associated to optimal expenditures. The extent to which firms’ expenditures are close to the optimal theoretical value depends on whether entrepreneurs are able to identify such a level. Drawing upon the entrepreneur’s human capital literature we further argue that deviations from the optimum are associated to particular individual characteristics of entrepreneurs.

A vast literature examines the relationship between entrepreneurial human capital and entrepreneurial success (for comprehensive meta-analyses see Unger et al. (2011), Martin et al. (2013)). An entrepreneur’s human capital facilitates further skill acquisition and the management of tacit knowledge and know-how, which are central to strategic management (Teece et al. 1997). As a

result, most scholars conclude that human capital is positively related to firm success (Bosma et al. 2004, Cassar 2006, Teece et al. 1997).

A particularly relevant proxy for human capital is entrepreneurial experience. Managerial ability of entrepreneurs is uncertain and resolves as they engage in the actual running of the business (Jovanovic 1982) and more experienced entrepreneurs make less erratic decisions (Robert Mitchell et al. 2011). Another proxy for human capital is the level of education. Entrepreneurs with high levels of education are usually associated with high general and specific skills, non-cognitive abilities such as discipline and motivation, and a larger network of individuals who can potentially facilitate firms' access to resources. Bates (1990), for example, finds that highly educated entrepreneurs are most likely to create firms that remained in operation after several years. There is reason to believe, therefore, that the entrepreneur's education will be associated with balanced expenditures decisions.

Entrepreneurial confidence is another key source of variation in strategic choices. Startup firms' managers may have different levels of confidence about their firms' capabilities and the potential payoffs from various strategic options (Johnson and Hoopes 2003). Overconfidence – an inflated sense of accuracy or ability in a specific domain (Åstebro et al. 2007) - is perhaps the most documented feature of entrepreneurial cognitive biases (see, e.g., Abdelsamad and Kindling (1978); Dosi and Lovallo (1997); Bernardo and Welch (2001); Fraser and Greene (2006); Lowe and Ziedonis (2006)).

Overconfidence on own competitive stance leads entrepreneurs towards bold decisions that may not be strategically sound. Cooper et al. (1986), for example, documents that out of 2994 entrepreneurs 81% believe their chances of success are above 70%, while in reality about 75% of new ventures no longer exist after five years. In fact, scholars have found a negative relation between measures of overconfidence and sound decision making (Hmieleski and Baron 2009, Gartner 2005). Lowe and Ziedonis (2006), for example, find that startup firms continue unsuccessful development efforts for longer periods than established firms, which is consistent with an overconfidence bias. Similarly, Åstebro et al. (2007) find that a majority of inventors continue to spend time on projects after receiving a highly diagnostic advice to cease effort. This is consistent with both overconfidence and over-optimism (the consistent belief that they are less likely than others to suffer from negative events and more likely to experience positive events). Although most of the literature suggests a

negative relationship between overconfidence (and optimism) and success, some studies argue the opposite. Optimism about own abilities and external conditions may help entrepreneurs to gather and develop resources required to survive (Baron (2007), p. 179; Wright and Staw (1999)). Baum and Locke (2004), and Hmieleski and Corbett (2008), for example, have documented evidence of a positive relationship between overconfidence about own ability to make sound entrepreneurial decisions and objective performance measures such as firm sales and employee growth.

Based on this literature we hypothesize that there should be a statistical relationship between entrepreneur's experience, education and confidence and a balanced spending strategy. In order to test these hypotheses, we estimate a model of absolute deviations from the optimal spending per employee as a function of entrepreneur's experience, education, and confidence. The KFS contains information on experience and education. Confidence is measured through a question that asks entrepreneurs to state whether they perceive their firm has a competitive advantage over competitors.

Our study makes three contributions. First, we study the relationship between spending per employee and firm survival. We empirically show that spending per employee is indeed a significant predictor of startup success: Firms experience survival benefits from spending, but extremely high "burn rates" may result in outcomes that threaten survival, resulting in a U-shaped relationship. If firms spend too much, the inefficient use of resources can lead to failure. This result suggests that keeping a balanced level of spending should be an essential motive for entrepreneurs.

Second, we investigate the underlying mechanism that leads to a balanced spending. The rate at which the entrepreneur spends the firm resources is among one of the most important decisions when running a business. It is perhaps one of the hardest decisions too. Start-up firms usually do not have established routines or lack the data to correctly decide how much to spend. They have to act quickly to convince customers, investors, employees and other stake holders about the profitability of the start ups' projects. The extent to which entrepreneurs cope with these challenges depends on how accurate their own estimations about the optimal spending are. Our statistical analysis shows that education and overconfidence are positively correlated with balanced firm spending, while work experience has no substantial effect. Our interest in education and experience and our particular focus on overconfidence contribute to a growing empirical literature in strategic management that connects managerial cognition (and biases) to decision making, and

ultimately to firm performance.

Third, investors and entrepreneurs are paying increased attention to the level of spending of startup firms. Apart from being a widely used indicator of ongoing performance, the so-called “burn rate” is a key managerial decision. The burn rate is an important concept, but could potentially provide different signals to investors. On the one hand, high spending per employee could mean the firm is taking the necessary steps to create a competitive advantage fast. On the other hand, it could signal irresponsible spending and risk losing the trust of early investors in venture. Perhaps not surprisingly, this duality has spurred a heated debate among practitioners in the past few years.

Is there an optimal “burn rate” for startups? We pursue a theoretical and empirical approach to study this question using data collected on new businesses in the US between the years 2004 – 2011 by the Kauffman Firm Survey, augmented with data from multiple other sources. The next section introduces the formal hypotheses we will be testing, followed by a description of the data, empirical approach and the results. We then conclude with a description of the limitations of our approach, implications and directions for future research.

## 2 Hypotheses

### 2.1 Expenditures and Survival

The level of expenditures incurred by de novo ventures is a key strategic choice that entrepreneurs make to achieve survival and profitability. De novo entrants may decide to follow an aggressive expenditure strategy to recruit and train highly skilled employees, generate early economies of scale, or encourage experimentation. Aggressive expenditures may also signal a deep pool of resources, further enhancing the perception customers and capital providers have about the ability of managers and owners to compete, adapt and survive. High expenditures may also signal the firm is undertaking “radical” research and innovation to replace the incumbent (Acemoglu and Cao 2010). Aggressive expenditures, however, may also be associated with fundamental inefficiencies in how management is running the firm. Small firms may not need to rely on high short term incentives to motivate workers and may not need to incur high monitoring costs. Firms may also run out of cash, purchase useless assets, or hire the wrong people. Increased expenses may further undermine the ability and the incentives to respond aggressively to competitors. When managers keep

firms learn, firms are likely to exploit the most profitable opportunities first. As firms aggressively incur expenses, managers may face problems in finding new net present value positive investment alternatives, and nevertheless, be forced to pursue potential value destroying alternatives.

**Hypothesis 1.** *There is a U-shaped relationship between a de novo entrant's expenditure per employee and the entrant's probability of failure.*

## 2.2 Entrepreneur Characteristics and Expenditures

Are managers' or owners' characteristics associated to efficient expenditure per employee? A vast literature in strategic management suggests managerial characteristics are associated to firms' performance. Performance levels of small firms have traditionally been attributed to managerial factors. Entrepreneur's human capital facilitates skill acquisition and the management of tacit knowledge and know-how, which are central to strategic management (Teece et al. 1997). As managers engage in the actual running of the business entrepreneurs who learn they possess high ability tend to survive, while those who learn they possess low ability may discontinue operations. As a result, more experienced entrepreneurs make less erratic decisions (Robert Mitchell et al. 2011).

**Hypothesis 2a.** *Entrepreneurs experience is negatively associated to deviations from a balanced expenditure strategy.*

Formal education is perhaps the most widely available measure of entrepreneurial human capital. Entrepreneurs with high levels of education are usually associated with general and specific skills, non-cognitive abilities such as discipline and motivation, and a larger network of individuals who can potentially facilitate firms' access to resources. General education or more specific entrepreneurship education has been found to positively correlate with entrepreneurship-related human capital assets and entrepreneurship outcomes (Martin et al. 2013). It is still an open question, however, which entrepreneurial decisions are better taken by educated entrepreneurs. In the context of our research, we claim that entrepreneurs with more years of formal training are more likely to balance spending.

**Hypothesis 2b.** *Entrepreneurs' education is negatively associated to deviations from a balanced expenditure strategy.*

Entrepreneurial beliefs are another key source of variation in strategic choices. Startup firms' managers may have different levels of confidence about their firms' capabilities and the potential

payoffs from various strategic options (Johnson and Hoopes 2003). Overconfidence on own competitive stance leads entrepreneurs towards bold decisions that may not be strategically sound. Scholars have found a negative relation between measures of overconfidence and sound decision making (Lowe and Ziedonis (2006); Åstebro et al. (2007); (Hmieleski and Baron 2009, Gartner 2005)).

**Hypothesis 3.** *Entrepreneurs confidence about the firm's competitive advantage is positively associated to deviations from a balanced expenditure strategy*

### 3 Data

To test our hypotheses, we use the Kauffman Firm Survey (KFS) confidential microdata (Robb et al. 2009). The unit of observation in our study is a new business in the United States founded in 2004. The Kauffman Firm Survey collected longitudinal information from 4,928 new firms that started in 2004. The firms constitute a random sample from approx. 250,000 businesses opened in the United States during 2004 listed in Dun and Bradstreet's (D&B) business database. The firms surveyed answered questions in annual follow-ups up to and including 2011 that contained questions about the firm characteristics, owner characteristics, financial status of the firm, operational details as well as location and environment characteristics experienced by the firm. While collecting the data the KFS used stratified sampling with different sampling probabilities for high-tech and women owned businesses. Our estimation procedures use the weights provided by the KFS to provide unbiased estimates of the results and avoid the issues created by non-uniform sampling.

We augmented the data with the US Census County Business Patterns (CBP) data on number of firms, employment and payroll distribution for MSAs and states and with the US BLS Occupational Employment Statistics (OES) data for statistics about specific occupations in different industries. This augmented dataset allows us to test the impact of different environments in which the firms operate on their survival rate. Specifically, the CBP data is used to compute competition, concentration and average payroll and employment metrics, while the OES data uses the distribution of professionals across the US to calculate an index that measures the fit between the new firm's demand for employees and the availability of talent in its geographical area of operation that matches this demand. We geographically segmented the firms according to the state in which they were founded. Prior literature has used states, MSAs or other regional measures (such as rings of

varying distances around the firms) for segmenting the firms. Our analysis showed that using both combined statistical areas (CSAs) of which there are 169 in the US, as well as states and other geographical regions (of which there are 56 in our data) produce similar results. Thus we present the results when firm are segmented by their state of location.

We considered firms that reported having zero employees as having one employee (typically the owner). We had decided not to exclude data for businesses without any employees as many startups today employ the founders initially without growing for longer periods of time. In addition, we suspect removing such small businesses would crate a censored view of firm failures, as many of them never grow beyond the initial founders prior to failure.

### 3.1 Dependent Variables

We constructed the following dependent variables to test the different hypotheses:

#### *Failure event*

Prior studies used multiple measures for firm success including output measures such as firm profit and sales and input measures such as the number of employees or investment levels. Following more recent literature we focus on firm failure as it is easier to measure accurately, and in addition it lends itself less easily to accounting manipulations. Robb and Watson (2012) contain a detailed discussion of the merits of our measure of choice for young firms. The variable is a longitudinal measure of firm survival. It takes the value 0 if the firm has been operational in the year of the survey, and 1 if the firm had failed (closed or went bankrupt). Our data had approx. 200 M&A events which we categorized as non-failures<sup>2</sup> with a value of 0.

#### *Deviation from Optimal Spending*

Our main hypothesis in the paper is that the non-linear relationship between firm spending and survival implies there is a level of spending which yields the lowest failure rates. We call this level of spending “optimal”. Hypotheses 2a, 2b and 3 make predictions about factors that correlate with suboptimal spending of the firm. To test these hypotheses, we use our model estimates to find an optimal level of spending and calculate the distance of the firm’s spending from this optimum.

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<sup>2</sup>The results are robust to removing those firms from the data or to re-categorizing the M&A’s as failures.

The deviation variable measures the absolute value of the difference between a firm’s standardized spending per employee measure and the estimated optimum using the model parameters.

## 3.2 Independent Variables

### *Spending per Employee*

As described in the introduction, a tradeoff exists between aggressive firm spending that encourages employees and allows for competition in the market and lean spending that conserves resources and allows firms to respond more quickly to competition. We chose to look at the total firm’s annual expenditure per employee as the main strategic choice of the entrepreneur. This spending may include decisions to increase the firm’s human capital, marketing effort, to develop new products or to invest in new equipment and capabilities. The total spending of a company is a measure which is easy to collect and monitor, and as a result many professional investors (such as venture capital firms) look at this metric to try to identify firms in distress<sup>3</sup>. In addition, since de novo firms many times do not have acceptable measures of efficiency, productivity and performance, investors use this measure to compare across portfolios of firms and identify outliers. A natural alternative to the firm’s spending per employee is using the average wage the firm pays as an indication of overspending. In our data, however, there is only a 0.44 correlation between total firm expenditure and payroll expenditure, and regressing firm expenditure on payroll only explains 19% of the variation in the data. The value is calculated as the firm’s total annual expenditure for the year that ended prior to the time of the survey divided by its total number of employees at the time of the survey, using the following survey definition: “Expenses are the costs paid for the operation of the business, including wages, salaries, interest on loans, capital leases, materials, etc.”. The value is standardized.

### *Entrepreneur’s Human Capital*

Recent research into the role of managers in efficiently allocating firm resources has determined that managerial capital plays an important role in the success of those firms (Anderson-Macdonald et al. 2014). To test this theory, we use the firm’s principal owner’s years of work experience as a proxy for managerial capital. We also use an education measure to proxy for human capital which

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<sup>3</sup>See, e.g., <http://www.inc.com/fred-wilson/burn-baby-burn.html> and <http://www.inc.com/business-insider/sam-altman-thinks-startup-burn-rates-are-getting-frightening.html>

is not experience related. The measure takes a value from 1 to 10, where 1 indicates less than 9 years of education up to 10 which indicates a graduate degree. Appendix A describes the coding of the variable.

### *Confidence and Optimism*

Another factor that influences a manager’s decision on spending is their beliefs about the future prospects of the company as well as their tacit knowledge unobservable by the researcher. Managers which are more optimistic regarding their firm’s position in the market may choose to take bigger risks by spending more and trying to grow more aggressively. We use a novel measure of the owner’s optimism to determine if it leads to less efficient spending. We emphasize that an owner’s optimism may be founded in reality and have good cause (i.e., the firm is doing well and has a truly bright future), while it may also be unfounded optimism stemming from subjective beliefs of the owner not congruent with the actual state of the world. To measure optimism, we use the following survey question: “A competitive advantage is something unique or distinctive a business provides that gives it an advantage compared to competitors. In calendar year YYYY, did [NAME BUSINESS] have a competitive advantage over its competitors?” As the analysis below will show, over 50% of the firms in our dataset claimed to have a competitive advantage over its competitors in the majority of the survey years. We are unable to tell using the data whether this belief is founded or unfounded and therefore refer to it as general optimism. The variable contains the difference between the firm’s stated belief and the median belief of the firms in the data within the same state, year and 2 digit NAICS code. As an example, if the firm answered “Yes” to the question above, and the median answer is “No”, the variable will be coded as 1, while it will be coded as 0 if the firm’s belief matches the median and as -1 if the firm’s belief is more pessimistic than the median.

### **3.3 Controls**

We categorize the controls we use in our analysis of firm failure into three categories: (i) idiosyncratic firm level decisions (ii) relative firm positioning in the market (iii) environment level properties which are the same for all firms in the same industry, location or both.

The firm level decisions and relative positioning are a result of entrepreneurial effort and decision

making, while the relative positioning and environment level properties contain measures which may not be controlled by the entrepreneur but may impact the firm’s survival rate. In our analysis of the factors contributing to firm spending, we categorize the variables into two categories: (i) firm owner factors and (ii) firm level factors.

### 3.3.1 Firm Level Decisions

#### *Growth, Growth<sup>2</sup>*

As described by Pe’er et al. (2014), there is a non-linear relationship between de novo firm survival and their growth in the number of employees. We use a standardized measure of firm’s employment growth over the previous year to control for this phenomena. By using this control variable, we expect to replicate Pe’er et. al.’s result as well as control for the endogeneity in the strategic choice an entrepreneur makes with regard to the number of employees to employ. The value is the difference between the firm’s number of employees in the current year and the past year, divided by the firm’s number of employees in the past year. Although it may seem that growth and the firm’s spending per employee capture similar effects, they are actually distinct measures. Growth in the number of employees measures the growth strategy the firm owners have elected to use, while the spending per employee measures how resources are allocated once the decision has been made to hire employees, buy equipment etc. Both measures can be seen as different dimensions of the firm’s strategic choices. The correlation analysis between the measures in the Results section also shows there is no clear relationship between these measures. The variable is calculated as following:

$$Growth_t = \frac{TotalEmployment_t - TotalEmployment_{t-1}}{TotalEmployment_{t-1}} \quad (1)$$

### 3.3.2 Relative Firm Positioning

#### *Relative Average Wage*

Firm’s decisions on employee salaries highly depend on the environment in which they operate. Specifically, competition over employees may be fiercer in specialized industries such as high-tech. In addition, firms can choose whether to pay above market rates in order to create higher human capital which will lower failure rates in the long run. We use a standardized measure of the firm’s relative expenditure per employee to the average wage paid by firms in the same industry and state

to control for the effect of this competition. This measure allows us to control for relatively higher human capital a firm chooses to employ with respect to its peer competitors and its impact on survival rates.

#### *Relative Assets*

We anticipate that wealthier firms will be able to both spend more per employee as well as face lower risk of bankruptcy. This variable measures the ratio between the firm’s total assets to the assets of other firms in the data to estimate the firm’s endowment position. Controlling for this position directly will eliminate this alternative explanation.

#### *Relative Employment*

Following previous literature (Pe’er et al. 2014, Wiklund and Shepherd 2003), we use the ratio of the firm’s number of employees to the average employment of firms in the same location and 2-digit NAICS sector to estimate whether the firm operates at an efficient level compared to its industry. We should notice, however, that previous studies were limited to manufacturing sectors where employment is a better indicator of efficiency compared to our data that spans all sectors.

### **3.3.3 Environment Properties**

#### *Agglomeration*

We use the standard measure from urban economics (Ellison et al. 1997, 2010) that accounts for the effects of labor market spillovers and other advantages born by concentration of industries in a specific geographic area. Prior literature (Pe’er et al. 2014) has shown there is direct correlation with firm survival from agglomeration. The measure is calculated as:

$$A_{nt} = \frac{T - (1 - \sum_s x_s^2)H_n}{T - (1 - \sum_s x_s^2)(1 - H_n)} \quad (2)$$

with  $H_n$  being the Herfindhal Index of the employment concentration in sector  $n$ ,  $T = \sum_s (x_s - n_s)$  and  $x_s$  is the share of state  $s$  in employment in all sectors, while  $n_s$  is that share for the specific 2-digit NAICS.

#### *Concentration of Local Market Competition*

We expect stronger competition in the local market to reduce the firm’s survival rate. We make use of the Herfindahl–Hirschman Index calculated using the CBP employment data for the firm’s 2-digit NAICS, State and year.

### *Labor Fit*

The firm’s location decision and ultimately its environment are determined by the entrepreneurs based on the availability of resources as shown in Alcácer and Chung (2014). The fact entrepreneurs may endogenously locate their firms given their prospects of finding employees may introduce bias in our data. We use the measure developed in Alcácer and Chung (2014) to mitigate potential endogeneity issues. The measure looks at the fit between the firm’s industry, its location choice and availability of employees in the occupations used by firms in the industry. The measure is calculated as following:

$$LaborFit_{nst} = \sum_o \left| L_{no} - \left[ \sum_{k=1\dots N} \frac{E_{kst}}{E_{st}} L_{ko} \right] \right| \quad (3)$$

When  $o$  indexes the different occupations,  $n$  is the 2-digit NAICS code, while  $N$  is the number of 2-digit NAICS codes available.  $s$  is the state of the firm.  $L_{ko}$  is the percentage of industry  $k$ ’s employment in occupation  $o$ .  $E_{kst}$  is the employment of industry  $k$  in location  $s$  at time  $t$ , and  $E_{st}$  is the total employment (across industries) for location  $l$  at time  $t$ .

### *Fixed Effects*

We control for the state in which the firm operates and the 2 digit NAICS industry code. These controls allow us to eliminate specific industry or local events that may have impacted survival. In addition, we included year fixed effects which capture the effect of national events (such as the 2008 financial crisis) as well as the age of the firm. We notice that the majority of prior research focused on the manufacturing sector (either in Canada or in the US). Our data contains a broad cross section of firms from multiple sectors and our results show a similar pattern across sectors.

### 3.3.4 Owner Factors

#### *Gender*

Prior research has shown that the gender of entrepreneurs corresponds to risk taking attitudes by entrepreneurs (Robb and Watson 2012) as well as susceptibility to hubris (Kuppuswamy and Mollick 2015). We therefore use the firm principal owner’s gender to control for both gender related risk attitudes or hubris. The value is 1 for male principal owners and 0 otherwise.

### 3.3.5 Firm Level Factors

#### *Credit Risk*

Riskier firms may have a harder time raising funding and in addition may deviate more from optimality because of their riskier nature. The D&B credit risk score attempts to quantify a firm’s ability to conform to its financial obligations. Riskier firms may be judged as such since they make less than optimal financial decisions. The score is a value between 1 and 5, with a higher score indicating higher risk and lower commercial credit rating.

#### *Assets per Employee*

Firms with more assets may be able to spend more, and the analysis shows that more assets correlate with lower firm failure rate. We use the firm’s total assets divided by its number of employees as an indication of its ability to spend more.

## 4 Models and Estimation

Our estimation is based on the following model:

$$failEvent_{inst} = F(\beta_1 EmpSpend_{inst} + \beta_2 EmpSpend_{inst}^2 + \vec{\gamma} \cdot \vec{C} + d_n + d_s + d_t) \quad (4)$$

$failEvent_{inst}$  equals 0 if the firm  $i$ , at location  $s$ , with 2-digit NAICS  $n$  did not fail during year  $t$ , and 1 otherwise.  $\vec{C}$  is a vector of controls described above, and  $n$ ,  $s$ ,  $t$  are NAICS, state and year dummies, respectively.  $EmpSpend$  is the standardized spending per employee.  $F$  is the hazard function we use to estimate our model. We performed the analysis using a logistic hazard function as well as a Cox proportional hazard model and the complementary log-log link for robustness. We

present results for the logistic model in this paper, though the results were similar for all three models. We removed as outliers the top and bottom 1% of firms both on the Growth and Spending per Employee measures. Our model corrects for censoring due to firm attrition as well as the non-uniform weights given to different sector sampling by the KFS.

Our second estimation looks at factors impacting the firm’s deviation from optimal spending in the following way:

$$absDev_{inst} = \alpha_1 Optimism_{inst} + \alpha_2 Experience_{inst} + \alpha_3 Education_{inst} + \vec{\gamma} \cdot \vec{C} + d_n + d_s + d_t \quad (5)$$

$absDev_{inst}$  is calculated as  $absDev_{inst} = |EmpSpend_{inst} - OptSpend|$  when  $OptSpend$  is calculated as the minimum point of the parabola generating the lowest failure rate that was estimated from the previous model. Specifically,  $OptSpend = -\frac{\hat{\beta}_1}{2\hat{\beta}_2}$ .  $Optimism_{inst}$  measures the principal owner’s confidence and optimism difference from the median in her state, 2-digit NAICS and year, while  $Education$  and  $Experience$  measure the principal owner’s education level and work experience in years. As before,  $\vec{C}$  is a vector of controls described above,  $n$ ,  $s$ , and  $t$  are NAICS, state and year dummies, respectively.

## 5 Results

### 5.1 Does firm spending predict failure?

Table 1 presents summary statistics of the variables presented above.

Variable	Obs.	Mean	Std. Dev.
Failure Event	13,737	0.0514668	0.220956
Spending per Employee	13,737	-0.0282172	0.0891038
Growth	13,737	-0.0520666	0.3570266
Relative Average Wage	13,348	0.0008664	1.120889
Relative Assets	12,828	0.9788832	1.45551
Relative Employment	11,269	0.3115225	0.9625929
Agglomeration (A)	11,269	0.0110571	0.0074814
Competition (H)	11,269	0.0029768	0.0072433
Labor Fit	11,269	-0.9740435	0.2110437

Table 1: Summary Statistics of variables entering Model 1 (firm survival model)

Although our dataset contains over 18,000 observations, approx. 1/3 were dropped for reasons of missing data. Table 2 displays the correlation matrix for the dependent variables and controls. We do not find substantial correlation between the independent and control variables reducing the

worry for colinearity of our data. Specifically, our spending per employee measure and growth measure have little correlation among them. Although employee growth increases spending of the firm, the lack of clear correlation shows that owners have many avenues to spend funds on firm growth and employee growth does not necessarily capture all the impact such spending may have.

	Failure Event	Spending Per Employee	Growth	A	H	Relative Assets	Relative Employment	Relative Average Wage	Labor Fit
Failure Event	1								
Spending Per Employee	-0.048	1							
Growth	-0.016	-0.059	1						
Agglomeration (A)	-0.03	-0.019	0.004	1					
Competition (H)	-0.027	-0.026	0	0.191	1				
Relative Assets	-0.043	0.257	0.065	-0.001	0.003	1			
Relative Employment	-0.024	0.067	0.083	0.034	-0.008	0.222	1		
Relative Average Wage	-0.015	0.279	-0.013	-0.002	0.117	0.076	0.022	1	
Labor Fit	0.007	-0.009	-0.011	-0.178	-0.119	0.006	-0.089	0.029	1

Table 2: Correlations among explanatory variables for the firm survival model

Table 3 presents the model estimation results when the different controls are added sequentially in each step. Models 1 and 2 test Hypothesis 1, while Model 3 onwards adds variables considered by Pe'er et al. (2014) and Alcácer and Chung (2014) as controls. The results confirm our hypothesis that the expenditure per employee exhibits a non-linear relationship to firm survival. Higher expenditures per employee lower the failure rate of firms (negative linear effect) yet after a certain point the effect reverses and increasing expenditure per employee increases failure rates (positive quadratic effect), confirming Hypothesis 1.

We also see that the results described in Pe'er et al. (2014) with respect to the growth of firms are replicated by our analysis and hold beyond the manufacturing sector. The marginal effect of spending per employee at the means of other variables equals -0.16 while the average marginal effect across all observations is -0.19, which we interpret as most firms in our data underspending compared to the optimum. This can also be seen from the estimation result, where using the the coefficient estimates for  $EmpSpend$  and  $EmpSpend^2$ , we can estimate the optimal spending per employee at about 0.28-0.3 standard deviations, while the mean in our data is approx. -0.028 while the median is a -0.063.

Figure 1 shows the non-linear effect for our data as predicted by the model using a quadratic fit. As can be seen, for a few firms the predicted failure rate is at least twice as high as firms that use the optimal level of spending.

Since using a quadratic model may prove misleading as described in Nelson and Nelson and Simohnson (2014). Figure 2 shows the result of fitting the two-linear model described in Nelson

	(1)	(2)	(3)	(4)	(5)
	Fail Event				
<i>EmpSpend</i>	-4.46921*** (1.08297)	-5.98590*** (1.11966)	-6.12268*** (1.11616)	-3.15049** (1.3342)	-3.25557** (1.33224)
<i>EmpSpend</i> <sup>2</sup>		9.87945*** (2.34396)	10.04445*** (2.34874)	5.72436** (2.77555)	5.81348** (2.76598)
<i>Growth</i>			-0.50095** (0.2001)	-0.69749*** (0.22541)	-0.68812*** (0.22596)
<i>Growth</i> <sup>2</sup>			0.25899* (0.15576)	0.51530*** (0.16551)	0.51300*** (0.16466)
<i>Relative Avg. Wage</i>				-4.69794 (5.4782)	-4.22377 (5.24237)
<i>Relative Assets</i>				-0.16676*** (0.06363)	-0.16513*** (0.06324)
<i>Relative Employment</i>				-0.04943 (0.12159)	-0.05475 (0.1167)
<i>A</i>					-1.4933 (10.00482)
<i>H</i>					-43.81217** (18.33772)
<i>Labor Fit</i>					1.00602 (1.01229)
<i>Wald_p</i>	0.00004	0.00003	0.04152	0.04168	0.02101
<i>N</i>	12,177	12,177	12,177	9,144	9,144

Standard errors in parentheses  
\*  $p < 0.10$  \*\*  $p < 0.05$  \*\*\*  $p < 0.01$

Table 3: Firm survival model estimation results

and Simohanson (2014) as supporting evidence for the non-linear effect of spending per employee on failure. We notice the decreasing linear line towards the minimum for too little spending, and an increase for too much spending, lending stronger evidence for our conclusion.

## 5.2 What features explain firm suboptimal spending?

The previous analysis has shown indications that a firm's spending level per employee is helpful at predicting firm failure. As most early stage firms are managed by their owners, we examine different characteristics of owners as well as their beliefs about the firm's future to determine how they influence the spending decision of the firm. Table 4 presents the summary statistics of the variables used in the model that estimates the factors contributing to a firm's deviation from optimal spending. We note that on average 56% of survey responders over the years have indicated

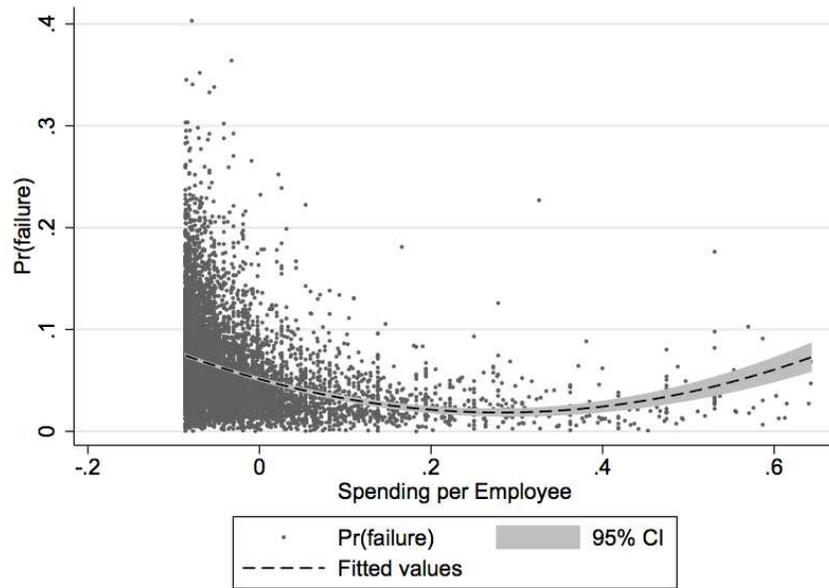


Figure 1: Predicted failure rate of firm (dots) and quadratic fit (dashed line). The shaded area is the 95% confidence interval around the fitted line.

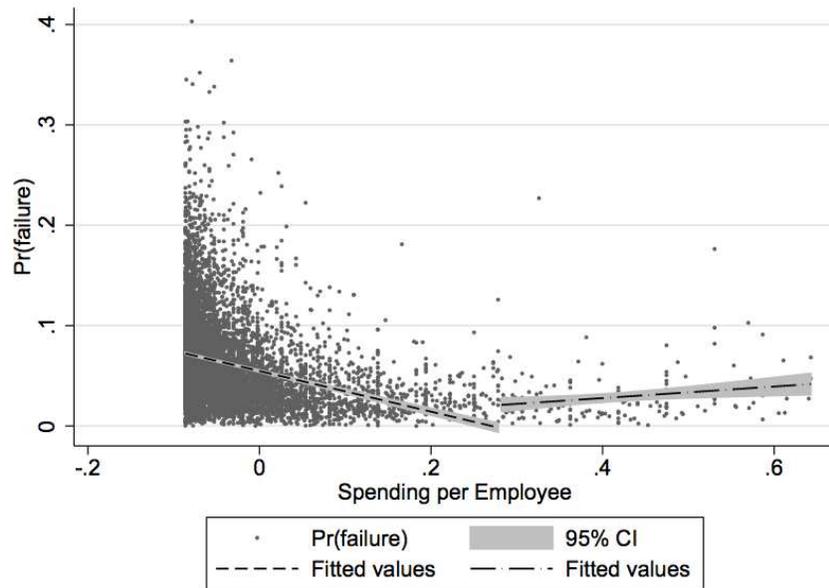


Figure 2: Predicted failure rate of firms (dots) and two linear fits, the left for dots below the minimum point, while the right is for dots above the minimum.

they have a competitive advantage, while the mean optimism in our data is negative.

Table 5 presents the correlation among the explanatory variables in our second estimation. As

Variable	Obs.	Mean	Std. Dev.
Comp. Advantage	13,697	0.566	0.496
Optimism	13,697	-0.079	0.488
Work Experience	13,509	13.603	10.969
Education	13,499	6.562	2.059
Gender	13,509	0.749	0.434
Credit Risk	12,076	2.94	0.932
Assets per Employee	12,920	-0.011	0.716

Table 4: Summary statistics for the deviations from optimal model

before we do not find substantial correlation between the variables, lowering the risk of collinearity in our model. In addition, we note that the Education and Work Experience measures are not as highly correlated as one might expect.

	Comp. Advantage	Optimism	Work Experience	Education	Gender	Credit Risk	Assets per Employee
Comp. Advantage	1						
Optimism	0.59	1					
Work Experience	0.0182	0.0002	1				
Education	0.0837	0.0308	0.0386	1			
Gender	0.0007	0.0208	0.1791	-0.0066	1		
Credit Risk	0.0219	-0.0128	-0.0643	-0.0832	-0.0089	1	
Assets per Employee	0.0124	0.015	-0.0063	-0.0045	0.0031	-0.0114	1

Table 5: Correlation matrix among explanatory variables in the firm deviation in spending model

Finally, Table 6 presents the estimation result of the OLS model that analyzes the firm’s deviation from optimal spending. Optimism and Education have a significant negative effect on distance from optimal spending, while work experience has a small effect that appears to be non-substantial and becomes non-significant with additional controls. Gender, which in our case serves as a proxy for overconfidence has similar impact while higher credit risk leads a firm to less than efficient spending, which may indicate resource constraints.

We note that adding the Assets per Employee control lowers the model fit, although this may be a result of the reduced number of data points available to the model. The results of the model estimates confirm the hypothesis 2b, while surprisingly do not lend evidence to support Hypothesis 2a. Hypothesis 3 is also not borne out by the data. A first order approximation using the model estimates and the marginal effect estimates from the firm survival model imply that increasing the level of optimism above the median correlates with a decrease of 0.2% in failure rate, while an increase in the level of education of one unit will correlate with a 0.1% decrease in failure rates. Although these numbers may seem small, we emphasize these are absolute and not relative measures. The failure rate of firms in our data is approx. 5% annually without weight correction (and approx. 9% with weight correction). A total decrease of 0.3% will mean a total decrease of

	(1)	(2)	(3)
	absDev	absDev	absDev
<i>Optimism</i>	-0.012*** (0.004)	-0.011*** (0.004)	-0.010*** (0.004)
<i>Work Experience</i>	-0.000* (0)	0 (0)	0 (0)
<i>Education</i>	-0.005*** (0.002)	-0.005*** (0.002)	-0.006*** (0.002)
<i>Gender</i>		-0.021*** (0.007)	-0.024*** (0.009)
<i>CreditRisk</i>			0.012*** (0.003)
<i>Assets per Employee</i>			0 (0.001)
<i>N</i>	13,420	13,420	11,102
<i>R<sup>2</sup></i>	0.616	0.617	0.579
Standard errors in parentheses			
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$			

Table 6: Results of firm deviations model estimate

3% – 6% in failure rates.

## 6 Discussion and Limitations

The burn rate of startups, while being a simple measure to extract has been rarely used in conjunction with more standard measures to predict firm failure. Our findings provide an approach that may allow decision makers, portfolio managers, analysts and investors to compare and analyze firms, identify distressed firms and explore what decisions entrepreneurs may take to increase their firm survival rates.

The analysis of startup data, especially one collected through surveys raises several potential limitations including location selection, missing data and other biases. As mentioned in Section 4, we performed the same analysis using a continuous time Cox model as well as a complementary log-log model with similar results. To control for the location selection of entrepreneurs we are extending our estimation using the models described in Bourguignon et al. (2007). Initial results did not indicate a substantial change in results. In addition, the KFS microdata has a separate

dataset that includes multiply imputed data that attempts to treat the issue of missing data in survey responses. We are currently analyzing this data and the results will be added as a robustness analysis to future versions of the paper.

## 7 Conclusion

In this paper we analyzed the association between the startup firms' spending per employee, also known as their burn rates, to the firms' failure rates. For our analysis we have made use of three datasets, the Kauffman Firm Survey, the U.S. Census County Business Patterns database and the Bureau of Labor Statistics Occupational Employment Statistics. We find that firms in our data that are able to balance their burn rates enjoy lower failure rates and longer longevity. Some of this effect may be explained by the impact of the owner's human capital, while some of the effect may be attributed to optimism and overconfidence that contributes to spending which matches the long term goals of the company. Future work that will include more refined information about the firm's allocation of financial resources to different internal functions as well as allocation of employees to these functions will be able to shed more light about the mechanism through which spending per employee affects firm survival rates.

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## A Coding of the Education Variable

Value	Education Level
1	Less than 9th grade
2	Some high school, but no diploma
3	High school graduate (diploma or equivalent diploma GED)
4	Technical, trade or vocational degree
5	Some college, but no degree
6	Associate's degree
7	Bachelor's degree
8	Some graduate school but no degree
9	Master's degree
10	Professional school or doctorate

Table 7: Coding of the Education Variable