Are Founders Non-Substitutable? Evidence from Nascent Firms where a Founder Dies*

Hans K. Hvide†

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Abstract

This paper tests an assumption from a large literature on financial frictions and credit constraints; that founders of new firms are non-substitutable. I exploit variation in founder death in a large sample of representative start-ups from Norway. Across a variety of tests, the results consistently point towards small adverse effects of founder loss on start-up performance. Although the findings do not imply that founders are fully substitutable, they suggest that, for representative start-ups, the degree of non-substitutability is surprisingly low. This finding has implications for both the likely source of credit constraints and for how we view the entrepreneur.

Keywords: contract theory, entrepreneurship, human capital, theory of the firm.

JEL codes: J23, D21, G39.

1 Introduction

Hold-up problems and asset specificity are central in economic theory, but much less empirical work has tested the assumptions underlying these models. This paper considers a

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†University of Aberdeen, Business School. Email: hans.hvide@abdn.ac.uk. Hvide is also affiliated with CEPR and NHH.

wide body of theoretical work on firms' investments in R&D (Anand & Galetovic, 2000), macroeconomic fluctuations (Kyotaki & Moore, 1997, Caballero and Hammour, 1998) and credit crunches and banking crises (Diamond & Rajan, 2001a, 2005).[1] Across this literature, a key assumption made is that founders of new firms are non-substitutable. Non-substitutability leads to hold-up problems, credit constraints, and inefficient levels of investment. The novelty of the paper is to test the assumption of founder non-substitutability.

To analyze the degree to which founders are substitutable one could study the performance of nascent firms where a founder quits. There is no reason to think, however, that entrepreneurs quit their firms in a random manner, and estimates of the value-added of a founder based on such endogenous events would likely be biased.[2] To obtain more reliable estimates of the importance of founders we would, as a thought experiment, take entrepreneurs out of nascent firms at random points in time, deport them to a desolate island without means of communication, and study how well their firms fare relative to a control group of firms where the founder stays engaged.

To learn more about the role of founders I use newly collected panel data from Norway on a large and representative sample of start-ups. The empirical strategy attempts to mimic the thought experiment by exploiting the random variation in the occurrence of founder death. If the operational role of founders is important, I would expect the loss of a founder to be associated with large adverse effects on firm performance. I analyze the performance of firms where a founder dies and compare it with the performance of firms where the founders stay alive. Differences in performance, after controlling for firm characteristics such as size and industry code, and founder characteristics such as age and prior wealth, are interpreted as due to the importance of the founder. For example, if nascent firms where a founder dies have a much lower survival rate than nascent firms where the founders stay alive, I would interpret this as support for the notion that founders

[1] The first paper in this literature, Hart & Moore (1994), showed that non-substitutability can lead to the firm being credit constrained. Other contributions include Almeida & Campello (2007) on corporate investment. An accessible paper that highlights the crucial role of founder non-substitutability for some of these theories is presented in Diamond & Rajan (2001b).

[2] For example, a founder leaving the start-up could indicate that the start-up is less promising or that there are serious conflicts between founders. This problem is analogous to the problem of estimating the value of CEOs to mature firms based on non-random CEO turnover, see e.g., Fee & Hadlock (2004).

have an important, and non-substitutable, operational role in nascent firms.

The data contains a sample of almost 7,000 firms started up between 1996 and 2003. In addition to yearly information about firm performance up to 2006, the data contains yearly sociodemographic information between 1993 and 2006 about founders with at least 10 percent ownership share. For every such founder, the sociodemographic data includes age, gender, income and wealth, and the year (but not the cause) of death. Of the about 12,500 founders in the sample, 181 decease before the end of 2006. More than two thirds of these founders have (at least) negative control in the company and almost half are majority owners. Although I observe the year of death, I am not able to observe whether founders die "unexpected" (e.g., heart attack) or "expected" (e.g., cancer). My estimates of the effects of founder loss on firm performance will therefore confound two types of effects: post-event disruptions due to founder loss and pre-event disruptions due to founder illness. Although these two effects are conceptually different, they are similar in both being expected to severely reduce founder productivity.

Using these unique data, I find only weak adverse effects on firm performance of the loss of a founder. For example, after controlling for founder and firm characteristics, I estimate that firms where a founder dies have 5 percentage points lower probability of surviving the first four years of operations. For six-year survival, the estimated drop in survival probability is about 6 percentage points. Quite strikingly, the estimated effects on sales and asset growth of founder loss, conditional on firm survival, are close to naught.

The main result of the paper is that founder loss has only small adverse effects on firm performance. I test this result for robustness in several ways. Most importantly, the panel structure of the data allows me to analyze changes in firm performance in a time window around the founder death event. Consistent with the cross-sectional analysis, I find weak effects of founder loss in the time-series analysis. For example, the one-year survival rate of nascent firms going into the year of death is lower than the one-year survival rate going out of the year of death. Moreover, the firms seem to experience healthy growth in assets and sales between the year prior to founder loss and the year after. Comparison with a control group of firms that do not experience founder death does not alter this conclusion; neither does confining attention to founders with a majority ownership share.

To accommodate that founder loss can have heterogenous effects across different types

of firms, I add interaction terms between founder loss and firm characteristics such as firm age at founder loss and dummies describing the size of the deceased founder's ownership share. The adverse effects of founder loss is larger for firms with only one founder, but even for this type of firms the adverse effects of founder loss seem far from devastating.

The paper is to my knowledge the first to provide evidence on the degree of substitutability of founders in nascent firms. The paper contributes to the empirical literature on contract theory by complementing recent evidence on asset-specificity and hold-up problems in the trucking industry (Baker & Hubbard, 2003, 2004).[3] My research considers the related theme of a firm's assets being specific to particular person, the founder. I go inside the black box of the nascent firm and analyze the importance of founders for the firm's productivity and growth. Although the findings do not imply that founders are fully substitutable, they do suggest that, for representative start-ups, the degree of non-substitutability is surprisingly low.

Chiappori & Salanie (2003) reviews the empirical literature on contract theory, including incomplete contracts, and highlights how self-selection makes inferences about the validity of model assumptions difficult.[4] For example, the influential Kaplan & Stromberg (2003) study 213 investments made by venture capital partnerships, and interpret the widespread use of non-compete and vesting provisions as evidence of the existence of a hold-up problem as in Hart & Moore (1994). The Kaplan-Stromberg findings apply to a selection of start-ups that have received considerable commitment from financiers. Companies where hold-up problems are severe are likely to not be able to receive venture capital funding. It is important to emphasize that rather than containing companies that have self-selected into a particular type of contract, my sample contains a representative selection of start-ups. This allows me to test theory assumptions without making inferences based on observed contracts.[5]

[3] Whinston (2001) reviews empirical work in the closely related literature on transaction-cost economics, and discusses the main differences to the property rights approach.

[4] The endogeneity of contracts is also emphasized by Prendergast (1999).

[5] Another way to confront the endogeneity problems is for the researcher to go inside the firm and explicitly randomize contract choices. This strategy has successfully been applied by Bandiera et al. (2005, 2007, 2009). An issue with this strategy is that there could be selection in the type of firms that are willing to let researchers in, which could make generalizations difficult. A different strategy to avoid endogeneity is to invite professional to the lab, and run experiments to understand their behavior outside the lab Fehr & List (2004) applies this strategy to a sample of CEOs.

Another challenge for the empirical contracting literature has been that the specific context considered by the theorist seldom exists in reality. As pointed out by Baker & Hubbard (2001), empirical researchers therefore tend to rely on generating hypotheses using auxiliary assumptions, and to apply these hypothesis to data. This strategy has the potential weakness that the auxiliary assumptions may or not apply to a more general context. The current paper avoids these problems by confronting the theory with data that is particularly close to the context considered by theory.

The paper is structured as follows. Section 2 discusses other related literature. Section 3 presents the data and some summary statistics, and Section 4 discusses the empirical strategy. Section 5 contains the basic results, and Section 6 analyzes the interaction between founder and firm characteristics and the effect of founder loss. Section 7 concludes.

2 Related Literature

I study whether entrepreneurs are substitutable after the firm has been started up. The paper is related to theoretical and empirical work on entrepreneurs, and to empirical research on the management and financing of young firms.

2.1 Entrepreneurship

While much work have presented evidence consistent with young firms being credit-constrained (e.g., Ando, 1985, Holtz-Eakin et al., 1994, Paulson & Townsend, 2004, Hvide & Møen, 2007, Aghion et al., 2008), much less is known about which frictions are important in creating these constraints occur; the theoretical literature suggests, for example, moral hazard (Aghion & Bolton, 1997), limited liability (Evans & Jovanovic, 1989), and adverse selection (Stiglitz & Weiss, 1981). My findings, at the very least, suggest that founder-specificity is not the only mechanism behind credit constraints and inefficient investment levels for very young companies.[6]

[6] This raises the question of which other mechanisms are more important for credit constraints, and the interplay between them. Paulson et al. (2006) use data from Thailand to estimate a structural model that encompasses both limited liability and moral hazard, but not founder-specificity, and finds that moral hazard is the main source of credit market imperfections.

Research on the returns to entrepreneurial activity suggests that the economic benefits for the entrepreneur is on average low (Hamilton, 2000, Moskowitz & Vissing-Jorgensen, 2001). This finding has been interpreted as that a main role of a start-up is to provide private benefits for the founders, such as more flexible work hours or a sense of control. While the current study has a different focus than Hamilton (2000) and Moskowitz & Vissing-Jorgensen (2001), my results stand in contrast to the private benefits view of entrepreneurship, simply because if a founder sets up a company to cater for his own needs, it seems most reasonable that the start-up would wither away without the founder's presence.

An old and unresolved question in the economics of entrepreneurship concerns the role of the entrepreneur (e.g., Rosen, 1997). Is the main role of the entrepreneur to discover business opportunities and conceive the firm or is it to run it? Schumpeter (1943), and later work in the Austrian tradition, emphasizes the role of the entrepreneur as a discoverer of new opportunities.[7] One interpretation of this view is that the entrepreneur is particularly crucial in the creative process underlying the formation of the firm, such as choice of location, target customers, and initial products. A more recent tradition emphasizes the entrepreneur as somebody whose primary talent is to mold a vague (or non-existing) business idea into a company through managerial skills and hard work.[8] While the first view considers the identity of the company as largely determined when the firm is started up, the latter view considers the human capital of the founder(s) as the important fixed factor, and the identity of the company as gradually emerging in response to the founder's actions. I find that entrepreneurs seem mainly substitutable after the firm has been started up, and therefore supports Schumpeter (1943). In the extension of that finding, a better understanding of how ideas are generated and molded into new

[7] Kirzner (1997) describes the position as: "What drives the market process is entrepreneurial boldness and imagination; what constitutes that process is the series of discoveries generated by that entrepreneurial boldness and alertness. [..] The process is made possible by the freedom of entrepreneurs to enter markets in which they see opportunities for profit." Sherwin Rosen (1997, p. 149) describes the view in similar terms: "Entrepreneurial activities are only possible when the nature of the world is not fully known, when knowledge and information are incomplete and dispersed [..] The entrepreneur is a person who exploits heretofore unrecognized opportunities."

[8] Although it does not directly follow from it, this latter view is consistent with critical resource theory as in Wernerfelt (1984) and Rajan and Zingales (2001), where a firm is "a web of specific investments built around a critical resource or resources." (Zingales, 2000). As pointed out by Kaplan et al. (2006), for nascent firms it is plausible to think of founders' human capital as the initial critical resource.

firms seems an important area for future research.[9]

2.2 Management and financing of young companies

A long-standing discussion in the venture capital community concerns whether the key determinant of the success of a young company is a strong business/market (the horse) or strong management (the jockey).[10] While venture capitalists would prefer to invest in young companies with both a strong business and a strong management team, different venture capitalists tend to resolve trade-offs differently. For example, Gompers and Lerner (2001) describe how Tom Perkins of Kleiner Perkins mainly considered a company's technological position, and Don Valentine of Sequoia assessed the size and growth of the market. On the other hand, Arthur Rock, an early investor in Apple, put more weight in the quality of the founding team. In support of the latter view, Gladstone and Gladstone (2002, p. 91-92) quotes an old saying as "You can have a good idea and poor management and lose every time. You can have a poor idea and good management and win every time." My results indicate that, in the context of this representative sample of start-ups, the horse is more important than the jockey.

Bhide (2000) interviewed the founders of 100 fast-growing companies from the Inc 500 list in 1989, and found that the founders typically did little formal planning before setting up a business, and the initial business idea was frequently adjusted in the first few years of operation. This evidence can be interpreted as the founder of these firms being more important as a "jockey" than as a discoverer prior to start-up. Kaplan et al. (2006) study strategy and management changes in a sample of 156 fast-growing companies that eventually go public. They find that between being venture capital financed and the initial public offering, almost none of these companies change their line of business, while the management team changes quite frequently. Thus for this sample of companies, the idea seemed more stable than the management team. Since all the companies in Bhide (2000) and Kaplan et al. (2006) were very successful, it was hard to evaluate whether the

[9] Motivated by evidence from Bhide (2000) that 71% of the entrepreneurs in his sample of fast-growing companies "[...] replicated or modified an idea encountered through previous employment," Hellmann (2007) and Hvide (2008) construct theories that model the interaction between idea generation while being an employee and the decision to quit the job and start up a company.

[10] For more details on this discussion, see Kaplan et al. (2006).

idea or the founders were more important to performance. In contrast to these papers, I study a representative sample of start-ups with considerable variation in performance. Baron and Hannan (2002) review studies of a panel of young firms from California. These studies show that initial models of employment tend to persist, and when the employment models are changed, employee turnover increases and performance declines. The studies do not focus on the role of the founders.

2.3 The value-added of executives to mature firms

The paper is also related to a large literature that considers the importance of executives to mature firms. Using data on large U.S. firms, Bertrand & Schoar (2003) find that manager fixed effects play a role for a large number of corporate decisions. Bennedsen et al. (2006a) and Bertrand et al. (2006) study the effects family control on corporate performance, and both find that the relationship is negative; Bennedsen et al. (2006a) finds that family successions have a large negative impact on firm performance, and Bertrand et al. (2006) finds that firms that are run by larger families tend to have lower performance. Worrel et al. (1986) study the stock market response of the death of 127 key executives of listed U.S. companies. They find that the effect of chairmen dying is neutral or even positive, while the effect of a CEO dying is negative. Bennedsen et al. (2007b) consider a large sample of (predominantly) non-listed firms from Denmark and find that the effect of manager death on firm profitability is negative.

The current study complements this literature by focusing on firms in their nascency. The management of such companies has considerable intrinsic interest for public policy and, from a methodological perspective, has the advantage that the individuals I consider have significant ownership stakes in their company and I am therefore unlikely to confound the main issue - the role of the founder in jockeying the nascent firm - with issues of weak corporate governance and managerial (or family) entrenchment.

3 Data and summary statistics

The sample consists of 6,800 limited liability firms that were incorporated in Norway between 1994 and 2002. The data is organized as a yearly panel ranging from 1992 to 2006, and contains incorporation and accounting information on the start-ups in addition to detailed sociodemographic information about all founders with at least 10 percent ownership share. I start out with a brief description of the Norwegian economy and the basis for the data collection (for a comparison with Sweden, see Calvet et al., 2007).[11] Norway is an industrialized nation with a population of about 4.5 million. The GDP per capita in 2002 is about $40,000 when currencies are converted at PPP; this is higher than the EU average of $26,000. Norway is characterized by a large middle class, and a lower inequality in disposable income than most other industrialized nations. Norwegian households are subject to both a capital income tax and a wealth tax every year throughout their lives.[12] Because of the existence of the wealth tax, the government's statistical agency, Statistics Norway (also known by its Norwegian acronym SSB) collects yearly data on wealth and income at the individual level from a variety of sources, including the Norwegian Tax Agency, welfare agencies, and the private sector. Financial institutions supply information to the tax agency on their customers' deposits, interest paid or received, security investments, and dividends. Employers similarly supply statements of wages paid to their employees.

The data is compiled from three different sources:

1. *Accounting information from Dun & Bradstreet's database of accounting figures based on the annual financial statements submitted to the tax authorities.*[13] This data includes variables such as sales, assets, and profits for the years 1992-2006. In addition, Statistics Norway were able to provide the 5-digit NACE codes for 82 percent of the firm-years. It is important to note that the D&B data contains all Norwegian incorporated companies, not a sample as in the U.S. equivalent.

[11] The following figures are taken from Statistics Norway Yearbook 2002 and 2003, available at http://www.ssb.no/aarbok/2003/.

[12] In contrast, the U.S. tax system requires wealth reporting only in connection with estate tax, which is imposed only on the very rich at the time of death (Campbell, 2006).

[13] Dun & Bradstreet is Bureau van Dijk's Norwegian subsidiary.

2. *Data on individuals from 1986 to 2006 prepared by Statistics Norway.* These records are based on government register data and tax statements, and include the anonymized personal identification number and yearly sociodemographic variables such as gender, age, education in years, taxable wealth, and income.[14] The records identifies the year of death (if applicable), but not the cause. This data contains all Norwegian individuals, not a sample as in the Panel Study of Income Dynamics or the Survey of Consumer Finance. As with the PSID and the SCF, the data are anonymized (i.e., does not contain names of individuals).

3. *Founding documents 1996-2003 submitted by new firms to the government agency 'Brønnøysundregisteret'.* These register data includes the start-up year, total capitalization, and the personal identification number and ownership share of all founders with at least 10 percent ownership stake.

For each new firm identified in 1) I compile a list of founders identified through 3) and match their associated sociodemographic information from 2). Due to alterations in the reporting requirement in 1997 I was able to match around 80% of the founders in companies founded after 1997 and around 20% before. We are then left with about 12,500 unique founders. For some firms, the first year of financial reporting, defined through 1), is later than the year of incorporation defined by 3). For these firms, I define the first year as the first year of reporting.

Similar to in other industrialized countries, setting up an incorporated company in Norway carries tax benefits relative to being self-employed (e.g., more beneficial write-offs for expenses such as home office, company car, and computer equipment), and incorporation status will therefore be more tax efficient than self-employed status except for the smallest projects. The formal capital requirement for registering an incorporated company was NOK 50,000 in equity until 1998 and NOK 100,000 thereafter. NOK 50,000 is equivalent to about 6,300 Euro. Incorporated companies are required to have an external auditor certifying the accounting statements in the annual reports.

An adverse consequence of the low barriers to starting up an incorporated company

[14] Earnings and wealth figures are public information in Norway. This transparency is generally believed to make tax evasion more difficult and hence our data more reliable.

and its favorable tax treatment, is that many start-ups, particularly within real estate, are tax-shelters or have minimal activity. This problem was dealt with in two ways. First, by over-sampling manufacturing and IT since tax shelters are less likely to occur in these industries. I selected all start-ups within the high tech sectors NACE 23-35 and 72 from 1994-1998, and all start-ups within manufacturing and IT, NACE 15-37 and 72 from 1999-2002. I added a random 25 percent sample of other non-financial private sector start-ups from 1999-2002. I expanded the sample after 1998 because the cost of collecting data for the more recent period is lower. Second, to further reduce the share of "empty shells" firms are included only if they have at least NOK 500,000 (about 63,000 Euro) in sales and at least two persons employed during one of the first two years of operation. Avoiding sampling empty companies is important as the incorporation documents had to be hand-collected by research assistants located in Brønnøysund.

We can note several advantages of our data compared earlier datasets on entrepreneurship, in particular work on the self-employed. First, since I study incorporations I can meaningfully distinguish between the life-span of the founder and the life-span of the firm. The empirical strategy of the current paper would be impossible with data on the self-employed. Second, I have access to a long panel with yearly and multiple measures of entrepreneurial performance. This enables me to perform a variety of robustness tests. Third, the data being organized as a panel, I have detailed data on the wealth and wage history of the founders. This enables me to control for founder human capital and liquidity in a detailed manner. As I know each individual's ownership stake, I am also able to analyze how the effect of founder loss depends upon the size of the ownership stake of the founder. Third, I have access to the industry codes of the start-ups, so that I can control for industry-specific effects.

Table 1a presents descriptive statistics of the firms and founders in the sample.

Table 1a: Summary statistics, first year

	d=0		d=1		Dfference	
Panel A: Founders	Mean	(St.dev)	Mean	(St.dev)		(St.error)
Age	40.0	(10.4)	54.2	(12.9)	14.2***	(0.96)
Years of education	12.3	(2.5)	11.2	(2.4)	-1.08***	(0.18)
Fraction male	0.87	(0.34)	0.88	(0.33)	0.01	(0.02)
Previous income (NOK 1000)	338	(270)	346	(245)	7	(24.7)
Previous wealth (NOK 1000)	864	(5,761)	1,370	(2,958)	505**	(300)
Ownership share	0.45	(0.27)	0.49	(0.29)	0.04**	(0.02)
Firm age at death	.	.	4.2	(2.6)	.	.
Dies before end 6th year			0.66	(0.42)		
N	12,571		181			
Panel B: Firms						
Start-up year	1999.6	(2.1)	1998.7	(2.02)	-0.92***	(0.15)
Equity (NOK 1000)	195	(572)	221	(625)	26	(46.7)
Number of founders	2.8	(1.4)	2.7	(1.5)	-0.11	(0.11)
Assets (NOK 1000)	2,364	(8,878)	3,475	(21,242)	1,111	(1,505)
No employees	3.9	(8.6)	4.9	(14.0)	0.98	(1.04)
Leverage ratio	0.88	(2.8)	0.78	(0.32)	-0.10***	(0.03)
IT	0.30	(0.46)	0.22	(0.41)	-0.08***	(0.03)
N	12,571		181			

The table depicts summary statistics of founders and the firms they start up, broken down on whether the founder dies (d=1) or not (d=0) before the end of 2006. Previous income and previous wealth are calculated as means over five years prior to start-up year. Number of founders is the number of founders with at least 10 percent ownership share. Leverage ratio is defined as book value of debt divided by assets. IT is defined as fraction of IT start-ups (NACE 72). Krone values are expressed in 2002 kroners. 1 euro equals about 8 kroner. *** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level.

Panel A contains summary statistics on the founders, evaluated in the start-up year, broken down on whether the founder dies (d=1) or not (d=0) before the end of 2006. Of the about 12 500 entrepreneurs, 181 (1.7%) are in the d=1 category. The firm is on average 4.2 years old when the founder deceases and 66 percent of the d=1 founders decease before the end of the sixth year of operations. Not surprisingly, the d=1 founders are on average older on the start-up date than the d=0 founders. They are also more wealthy, have a slightly higher ownership share in the firm, and about one year less of education on average. Panel B describes summary statistics for firms, broken down on

the realization of d.[15] The firms that loses a founder are somewhat larger both in terms of initial equity, assets, and the number of employees. Since being older is correlated with both higher mortality rate and a higher wealth, these findings are not surprising.[16]

For the sample as a whole, the founder descriptives are close to that reported by previous studies using U.S. data (Hamilton, 2000, Hurst & Lusardi, 2004, or Campbell, 2006). Founders tend to be experienced workers, on average 40 years old, and are relatively wealthy. Start-ups are small, on average they have NOK 2.3 million (about Euro 285,000) in assets at the end of the first year, with the median being considerably lower.

Since founder ownership share and firm age at founder death will be central variables in the analysis, I provide statistics on their joint distribution in the following table.

Table 1b: Founder ownership share vs. firm age at founder death, obs. per category

Ownership share:	Small	Neg. control	Majority	Sole owner	Sum (%)
Firm age:					
f$\leqslant$2	12	4	10	4	30 (16.6%)
2<f$\leqslant$4	12	11	11	10	44 (24.3%)
4<f$\leqslant$6	18	12	9	10	49 (27.1%)
6<f$\leqslant$8	8	10	9	10	37 (20.4%)
8<f$\leqslant$11	8	4	8	1	21 (11.6%)
Sum (%)	58 (32.0%)	41 (22.7%)	47 (26.0%)	35 (19.3%)	181 (100%)

The table depicts the joint distribution of firm age at death (f) and ownership share for the 181 founders with d=1. Each cell contains the number of founders by category. "Small" means that the ownership percentage is on the interval [10, 33.3), "Neg. control" means [33.3, 50), "Majority" means [50, 100) and "Sole owner" means 100 percent.

The table depicts the joint distribution of founder ownership share and firm age at death, by category. For example, 12 individuals have a "small" ownership share (less than one third of the firm's equity) and die before the end of the second year of operations,

[15] Panel B treats each founder as an independent observation. Treating each firm as an independent observation gives the same overall picture. Two firms had two d=1 founders (neither firm survived more than four years of operations, and neither founder held a majority position). No firms had more than two d=1 founders.

[16] Several papers have demonstrated a positive relation between founder wealth and start-up size, e.g., Ando (1995), Holtz-Eakin et al. (1994b) and Hvide & Møen (2007). This relation is usually interpreted as evidence of liquidity constraints being binding.

while 10 sole owners die in the fifth or the sixth year of operations. One fifth (19.3 percent) are sole founders, while 54.7 percent (32.0 percent + 22.7 percent) have less than 50 percent ownership. The correlation coefficient between ownership share and firm age in year of death is 0.00 and the spearman rank correlation is 0.04.

4 Empirical strategy

The question I ask is how important a founder is to the performance of a nascent firm. Answering this question is difficult because we usually do not observe the quantity (and quality) of a founder's input to the nascent firm, and if we do it is likely to be non-random. To exploit variation between nascent firms with respect to founder death provides an opportunity to tackle these estimation problems. My empirical strategy is to exploit the random variation in the occurrence of founder death to identify the causal effect of founders to newly started firms.

To analyze the effects of founder loss on firm performance, I initially focus on a cross-sectional formulation. The cross-sectional regression model explains, for each founder, the performance of his start-up in the following manner,

$$\text{Start-up performance} = \beta(\text{founder characteristics}) + \gamma(\text{start-up characteristics}) + \lambda d + \epsilon \tag{1}$$

where d is an indicator variable that equals 1 if the founder dies before the end of 2006 and equals 0 if not. I wish to estimate λ, which will be interpreted as the economic magnitude of how much start-ups rely on a founder. If founders are important and non-substitutable to nascent firms the estimated λ should be large and significant.

The founder characteristics I employ as controls are age, gender, years of education, prior wealth, and prior income. These variables are important to include for two reasons. First, since they proxy founder human capital and liquidity they can predict start-up

performance directly. Second, and more importantly for our purposes, it is well-known that age, gender and wealth are closely related to mortality rate (e.g., Gardner & Oswald, 2004). Thus including these founder variables as controls makes it more plausible that d is uncorrelated with the error term in (1) and therefore that λ can be interpreted as a causal effect.

The main start-up characteristics used in the regressions are size and industry code, both evaluated in the start-up year. Although including these controls may not be necessary to identify λ, as they are less likely to affect death probability than the founder controls, they can be useful to reduce the standard errors of the estimates. As performance variables, I use survival, profitability, employment, sales and level of assets, all described in more detail at the end of the section.

Although I observe the year of death, I am not able to observe whether founders die "unexpected" (e.g., heart attack) or "expected" (e.g., cancer). The cross-sectional estimates of the effects of founder loss on firm performance will therefore confound two types of effects: post-event disruptions due to founder loss and pre-event disruptions due to founder illness. Although these two effects are conceptually different, they are similar in both being expected to severely reduce founder productivity.[17]

In the cross-sectional regressions, I evaluate performance after six years of operations. On a six-year horizon, more than two thirds of the d=1 founders have deceased (see Table 1b). Since cancer is the cause of death in approximately a third of the cases, it is reasonable to assume that at least a third of the founders that have not deceased yet are seriously ill in the sixth year. On a six-year horizon we would therefore expect strong

[17] Aggregate statistics can inform us of the likely causes of death across the d=1 group. Statistics Norway (2006) contains frequencies for causes of death for Norwegian citizens in 2006, broken down on gender and age groups. Matching the age and gender characteristics of the $d = 1$ founders in Table 1a with Statistics Norway (2006) suggests that the most common cause of death is cancer (33 percent) and heart decease (22 percent). The heart decease category includes stroke. The most common other predicted causes of death are accidents (9 percent), deceases of the respiratory system (5 percent), and suicide (5 percent).

adverse effects on firm performance for about 80 percent of the $d = 1$ founders.[18] I also evaluate performance after four years. Doing the same type of calculations for the four-year horizon, we would expect strong adverse effects on firm performance for at least 60 percent of the $d = 1$ founders.

To deal with possible omitted variable bias in the cross-sectional regression (1), I additionally use a time-series regression model. In the time-series model, I compare start-up performance one year before and one year after the death event, and interpret lack of growth or worsened profitability as evidence of adverse effects of founder loss. To evaluate the changes in firm performance around the founder death event against a benchmark, I construct a control group of firms where the founder does not die by matching on first-year firm and characteristics (Appendix A describes how the control group was constructed and gives some summary statistics). I then calculate the mean change between year t-1 and year t+1 for the control group and compare it with the corresponding difference for the d=1 group.

Cancer in particular is typically associated with a preceding period of illness that could adversely affect the founder's productivity well before the death event. While the the time-series model is better equipped to deal with omitted variable bias, the cross-sectional regression model is better equipped to deal with such effects that accummulate over time. If there are large effects of founder death, I find it highly unlikely that they will not be captured by either the cross-sectional or the time-series regression models.

To accommodate that founder loss can have heterogenous effects, I perform two types of additional analysis. In Section 5, I limit the analysis to majority founders, as adverse effects of founder loss are presumed to be especially large for this group. Second, Section 6 considers a variation of (1) where I add interaction terms between d and founder and firm characteristics. The most important interaction terms are firm age at founder death

[18] A six-year horizon reduces the d=1 founders by 7 percent (and the number of founders in the sample by about 20 percent), since these founders started up a firm after 2001.

and the size of the founder's ownership share. For the latter interaction term, I create dummy variables that relate to the size of the founder's ownership share, as defined in Table 1b.

I now discuss reverse causality and omitted variable bias in more detail.

Reverse causality

To avoid that start-up performance directly affects the measures of founder and firm characteristics associated with β and γ in (1), I evaluate the founder and firm characteristics at the start-up date. The more serious form of reverse causality is that start-up performance could affect founder death probability, in which case d could not be seen as an exogenous event. The health literature documents that increased death probability is associated with "bad" stress, i.e., a combination of high work demand and limited ability to cope with it, rather than high work demand by itself.[19] This suggests that a possible effect from performance to death probability should primarily be for founders where the firm performs badly. Thus reverse causality should, if present, bias our estimate of λ away from zero (towards minus infinity).

An indirect way of assessing the importance of reverse causality between start-up performance and founder death is to investigate whether entrepreneurs have a higher death probability compared to non-entrepreneurs with the same socioeconomic characteristics. As a simple way to investigate this question, I sampled 50,000 persons that were alive in 1995 from the Norwegian population at large, and ran a probit regression where the dependent variable was whether the person dies before the end of 2006 or not. The right hand side variables were age, gender, income and wealth in 1995, in addition to a dummy if that person were a founder. The regression suggested that founders had about 1.5 percentage points lower probability of dying before the end of 2006 than non-

[19] For example, Kivimäki et al. (2002) finds that after controlling for age and gender, individuals with high job strain (a combination of high demands at work and low job control) had a 2.2-fold cardiovascular mortality risk over a 25 year period compared to individuals with low job strain. Gardner & Oswald (2004) reports similar findings taking mortality as dependent variable.

founders, an effect that was highly statistically significant. I also ran a specification where I included an interaction term between death and the ownership share of that individual, to investigate whether founders with a larger ownership stake had a higher death probability. This term was positive but close to zero and highly insignificant. Including municipality fixed effects and squared sociodemographic terms did not change the results. These results do not suggest that founders have a higher death probability than comparable non-entrepreneurs.[20]

Omitted variable bias

The second issue with interpreting λ as a causal effect is that omitted variables could make the residual in (1) correlated with the death probability. It could then appear as death is driving performance while it would in fact be the omitted variable.

An obvious candidate for omitted variable is the health status of the founder. Ill health could affect both the founder's probability of dying and firm performance through productivity effects on the founder. It is useful to consider two possible scenarios. The most straightforward one is that founder ill health occurs unexpectedly after the start-up date. Estimates of λ would then combine two effects: pre-death loss in founder productivity due to illness and post-death effects of founder absence (replacing the founder, possibly with less productive people, or reducing the scale of the firm). This scenario is less of a worry, as both effects would be a causal effects going from founder presence to firm performance, where the identifying assumption would be that illness is unanticipated at the start-up date.

The second scenario is that founder ill health is anticipated (or present) at the start-up date, and that the founder adjusts the start-up characteristics in order to dampen

[20] A more direct way to test for reverse causality would be to see whether a bad performance one year leads to a higher death probability the next year. Analysis of this question suggested a negative but insignificant relation between profitability one year and death probability the next year. This test may not be appropriate as bad founder health is likely to affect both current profitability and subsequent death probability, i.e., the result may be due to omitted variable bias rather than reverse causality.

the effects of illness. Possible adjustments to the firm could be having a lower initial capitalization or by recruiting additional founders as back-up, adjustments that quite possibly also could dampen the effects of founder loss. Since I do not have access to the health record of the founders, I cannot separate "sudden" from "anticipated" loss of a founder, and hence cannot fully account for the possibility that the founder adjusts the initial firm characteristics in view of ill health. If such conscious adjustments were the case, however, I would expect firms of d=1 founders to be different along observable characteristics at the start-up date than firms where the founder stays alive. To investigate this question, I regress the firm variables initial equity, number of founders, number of employees, and assets on d. I include controls for the founder variables age, gender, education level, previous income, and previous wealth, to accommodate that the d=1 founders are older and more wealthy than the d=0 founders.

Table 2: Comparing firms, first year

	Panel A: all founders		Panel B: majority founders	
Dependent variable	λ	R^2	λ	R^2
(1) Log equity	0.045	0.16	0.055	0.23
	(0.057)		(0.086)	
(2) Number of founders	-0.057	0.05	0.050	0.02
	(0.116)		(0.111)	
(3) Log employees	0.015	0.10	-0.012	0.12
	(0.064)		(0.107)	
(4) Log assets	0.056	0.15	0.114	0.19
	(0.082)		(0.117)	
(5) IT	0.016	0.11	0.063	0.15
	(0.39)		(0.065)	
N	12,610		5,408	

Each row is a separate regression where the dependent variable is given in the first column. The second column is the estimated λ in each regression, i.e., the partial correlation between founder death and the dependent variable. Founder variables (age, age squared, gender, years of education, log previous income, and log previous wealth) and start-up year are included as controls. In (1)-(4) two-digit industry code are also included as controls. The definition of a majority owner is an owner with at least 50 percent ownership. The estimation method is ordinary least squares in (1)-(4) and probit in (5). In (5), the marginal effect is reported. Robust standard errors clustered at firm level in parenthesis. *** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level.

Panel A (B) investigates whether firms where the (majority) founder dies (d=1) are different at the start-up date than firms where the (majority) founder stays alive (d=0). The table does not suggest the presence of systematic differences at the start-up date between firms where the founder dies and firms where the founder stays alive, controlling for observable characteristics of the founder; the estimated coefficients are both small and statistically insignificant. Given the many undoubtable strains with starting up a company, a plausible explanation is that persons that expects to be ill would not start up a firm at all.[21]

Performance measures

I measure firm performance by three different measures. The first measure is business survival. A firm is defined to have survived t years of operations if it reports a (negative or positive) profit and has at least NOK 50,000 in sales in year t+1. Survival provides a simple measure of performance but is rather crude; for example lack of survival could mean that the firm has been bought up or that the entrepreneur closes it down due to better opportunities in the labor market. The second measure is profitability, as measured by operating returns on assets (OROA). OROA is the standard performance measure in a large accounting and financial economics literature (see e.g. Bennedsen et al., 2007a, and the references therein) and defined as the ratio of earnings before interest and taxes (EBIT) to the total asset base used to generate them. Unlike returns on equity or returns to capital employed, OROA compares firm profitability relative to total assets. In contrast to net income-based measures such as return on assets, OROA is not affected by capital structure or dividend policy differences across firms. As asset base when calculating OROA, I use the average of the assets at the end of year t-1 and at the end of year t. To avoid that outliers drive the results, I winsorize the yearly OROA values at the 5 percent level. Neither survival nor profitability measure start-up growth, which measures value

[21] This assertion is partially validated by the finding reported above that founders do not appear to have a higher death probability relative to the rest of the population.

potential and job creation. I therefore add sales, number of employees, and total assets as third measures of performance.

Of alternative performance measures, the most natural would be to analyze the frequency to which firms in the sample go public, and their market value at the initial public offering. The number of firms in the sample that become listed before the end of 2006 is too small to perform a rigorous statistical analysis, but their considerable value creation still makes them of more than anecdotal interest. These firms are considered at the end of Section 5.

5 Basic results

The following table reports summary statistics on d=0 founders and d=1 founders.

Table 3: Performance summary, all founders

	d=0		d=1		Difference	
	Mean	(St.dev)	Mean	(St.dev)		(St.error)
Panel A: Survival						
3-year survival	0.77	(0.42)	0.76	(0.43)	-0.02	(0.03)
4-year survival	0.71	(0.46)	0.67	(0.47)	-0.03	(0.04)
5-year survival	0.65	(0.48)	0.61	(0.49)	-0.04	(0.04)
6-year survival	0.61	(0.49)	0.59	(0.49)	-0.03	(0.04)
Panel B: 4th year:						
Employees	5.7	(10.1)	6.6	(14.4)	0.96	(1.24)
Assets	3,962	(13,576)	4,576	(19,261)	614	(1,651)
Sales	6,849	(15,461)	7,130	(11,200)	281	(970)
OROA, year 2-4	0.12	(0.34)	0.11	(0.35)	-0.01	(0.02)
Panel C: 6th year:						
Employees	6.3	(11.7)	8,1	(18,8)	1.8	(1.9)
Assets	4,959	(19,599)	7,475	(37,704)	2,515	(3,759)
Sales	8,157	(18,990)	9,108	(18,941)	951	(1,899)
OROA, year 2-6	0.13	(0.33)	0.12	(0.32)	-0.01	(0.02)
N	12,568		181			

A firm is defined to survive year t if it reports a non-missing profit and at least NOK 50,000 in sales in year t+1. Assets and employees are evaluated at the end of the year. OROA in year t is computed using

the average of assets at the end of year t-1 and at the end of year t. The number of OROA observations in Panel B (C) is 24,563 (24,324) for d=0 and 347 (424) for d=1. Krone values are expressed in 2002 kroners. *** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level

Panel A reports the mean survival rates of the start-ups of the d=1 founders (the third column) with the start-ups of d=0 founders (the first column). Panel B reports size and sales after four years, and profitability during the first four years, broken down on founder type. Panel C reports the same as Panel B but on a six-year horizon. This first cut of the data does not suggest that the loss of a founder has very strong negative effects on the firm. For example, six-year firm survival rate is 61 percent for d=0 founders and 59 percent for d=1 founders.

Founders that die are older, wealthier, and are less likely to start up a firm in the IT industry. In the following regressions, I investigate firm performance controlling for founder and firm characteristics at the start-up date. The founder control variables include age, age squared, gender, previous income, and previous wealth, while the firm control variables include size (log equity at the start-up date), two-digit industry dummies, and start-up year.

Table 4: Performance regressions, all founders

	Panel A: after 4 years			Panel B: after 6 years		
Dependent variable	λ	R^2	N	λ	R^2	N
(1) Survival	-0.051	0.02	11,685	-0.064	0.02	8,034
	(0.039)			(0.044)		
(2) Log employees	0.040	0.11	9,776	0.059	0.09	6,598
	(0.069)			(0.101)		
(3) Log sales	0.062	0.17	9,776	0.019	0.12	6,598
	(0.106)			(0.146)		
(4) Log assets	-0.003	0.19	9,776	0.012	0.15	6,598
	(0.097)			(0.138)		
(5) OROA (year 2-)	-0.006	0.03	24,595	-0.015	0.03	24,352
	(0.027)			(0.026)		

Each row in Panel A (B) gives the estimation results for a separate regression where the dependent variable is given in the first column in the table. The first column in Panel A (B) is the estimated λ in each regression, i.e., the effect of founder death (d) on the dependent variable. In Panel A (B), the dependent variable is evaluated after four (six) years, except for in row (5) where performance is

evaluated in the second until the fourth (sixth) year. Founder variables (age, age squared, gender, years of education, log previous income, and log previous wealth), firm variables (log equity, two-digit industry code), and start-up year are included as controls in (1)-(4). In (5), firm age dummies are included as controls. The estimation method is ordinary least squares in (2)-(5) and probit in (1). In (1), the marginal effect is reported. Robust standard errors clustered at firm level in parenthesis. NOK 10,000 are added to previous income, previous wealth, assets and sales before taking logs.*** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level

In the first four rows of Panel A, I regress measures of firm performance after four years on the explanatory variables, and in row (5), I use each individual-year as an independent observation. Across rows (1)-(5), neither the size or the significance level of the estimated coefficient suggest a strong effect of founder loss. The only coefficient that is close to being significant is on survival. The estimated coefficient on survival suggests that firms that lose a founder has about 5 percentage points lower four-year survival probability. In row (5), the relation between founder loss and yearly profitability is weakly negative and insignificant. The results in Panel B speak to firm performance after six years of operations. The results are very similar to in Panel A, in that the only coefficient that is close to being economically or statistically significant is on survival probability. The magnitude of the coefficient on survival is similar to the coefficient on four-year survival; firms that lose a founder have about 6 percentage points lower six-year survival probability. Since the results suggest very weak negative effects of founder loss it seems unlikely that reverse causality, as discussed in Section 4.2, plays an important role.

I have extensively investigated whether the weak results in Table 4 could be due to mis-specification of the right hand side in (1), by conducting robustness tests. Across these tests, the results are very similar to those reported in Table 4. First, I reran the regressions after dropping the individuals that decase after the sixth year of operations. Second, I ran the regressions on yearly observations, using one-year survivor probability, sales growth, employment growth, and asset growth as dependent variables rather than sales, employment, assets and survival after four (six) years. The estimated coefficients

are not closer to being economically or statistically significant than in Table 4. Third, I have run the regressions on firm level rather than on founder level. In these regressions I kept only one yearly observation per firm and defined a dummy that equals one if at least one of the founders dies. Finally, I have rerun the regressions including squared terms on the main explanatory variables such as wealth and income of the founder and the size of the firm, tried using one sector industry codes, used median regressions rather than ordinary least squares, and excluded firms where a firm (rather than an individual) is the largest founder.

One may ask whether the statistical tests have sufficient power to reject the null hypothesis of no difference between the two groups. To examine this question, say that the true four-year firm survival rate for the d=0 group of founders is 10 percentage points higher than the true survival rate of the d=1 founders. Using the estimated standard deviations from Table 3, a one-sided 10 percent level t-test on differences in survival rate has 95 percent power, meaning that the null hypothesis will be rejected at the 10 percent level with a 95 percent probability. The corresponding power of a test of a 10 percentage points difference in OROA is 100 percent.[22] Doing the same type of exercise, but now assuming that the true difference in survival rates is 5 percentage points, gives a test power of approximately 60 percent for survival and 95 percent for OROA. The joint power, i.e., the probability of accepting both null hypotheses given that both are false would thus be higher than 95 percent. These calculations suggests that the lack of evidence of strong differences between the d=0 group and the d=1 groups is not due to low power of the tests.

Another reason for the weak results could be that omitted variable bias, as discussed in Section 4, skews the estimated coefficients towards zero. To assess this possibility, I

[22] To accommodate that within-firm observations of ROA are correlated, I also calculated the power of the test if the stated number of observations equals the number of firms rather than the number of founder-years. The power of the test is then 99 percent. The numbers are calculated using the sampsi command in Stata.

now consider within-firm effects of founder death, by analyzing changes in performance in a time window one year prior to and one year after the founder loss event.[23]

Table 5: Changes in performance around loss event

	Mean_{t-1}	Mean_{t+1}	Change	Mean_t	N	Δ
Dependent variable						
(1)Survive	0.867	0.931	0.064*	0.929	120	0.043
	(0.031)	(0.027)	(0.043)	(0.026)		(0.038)
(2)Sales (NOK 1000)	5,509	6,271	762	6,381	81	-60
	(6,373)	(7,829)	(1,122)	(7,497)		(713)
(3)Employees	5.432	5.506	0.074	6.000	81	-0.157
	(6.299)	(5.838)	(0.954)	(6.604)		(0.586)
(4)Assets (NOK 1000)	2,529	2,758	228	2,803	81	-75
	(2,716)	(3,538)	(496)	(3,062)		(490)
(5)OROA	0.122	0.153	0.031	0.156	67	0.060*
	(0.291)	(0.245)	(0.047)	(0.306)		(0.041)
(6)Industry change	0.205	0.159	-0.045	0.262	44	-0.028
	(0.062)	(0.056)	(0.083)	(0.074)		(0.089)

The table reports firm performance in year t-1, t, and t+1, where year t is the death year. A positive change in the third column means an increase from year t-1 to year t+1. A positive value for Δ in the sixth column means that the d=1 group had a greater increase than the control group. A firm has survived year t if it is active in both year t and in year t+1. It has not survived year t if it is active in year t but not in year t+1. A firm is active in year t if it reports non-missing profits and at least NOK 50,000 in sales for year t. Standard deviations in parenthesis except in the first row and in the last column where standard errors are reported. *** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level.

The first column shows means for the firms one year prior to founder death (year t-1), and the second column shows mean for the firms one year after founder death (year t+1). The third column is the mean change in firm performance between the year before founder death and the year after.[24]

[23] To accommodate possible trends, I also extended the window to two years before and two years after the event. The results are very similar to in Table 5, and not reported.

[24] Compared to the 181 individuals in the cross-sectional analysis, the number of founders in the panel analysis is reduced for the following four reasons. (i)For (1)-(5) we lose 14 individuals that die before the end of the first year, since statistics in year $t-1$ are non-existing for these individuals (167 remains). (ii)In (1)-(5), we lose additional 47 individuals because the firm closed down before year $t-1$, since statistics in year $t-1$ are non-existing for these individuals (120 remains). (iii)For (2)-(5) we lose 39 individuals either because the firm closes down between year $t-1$ and year $t+1$ or because $t+1$ is later than 2006 (81 remains). (iv)For the OROA analysis in (5) we in addition lose 14 individuals that die in the second year of operations, as OROA in a given year is computed from the average asset base that year and the

Table 5 does not suggest that the loss of a founder has a strong detrimental effect on the firm. On survival the first entry in row (1) reports the mean survival rate between year t-1 and year t as 87 percent. This number is smaller than both the one-year survival rate in year t (93 percent) and the one-year survival rate in year t+1 (also 93 percent). The improvement in one-year survival rates from year t-1 is statistically significant at the 10 percent level. As way of comparison, the entries in row (1) are very similar to the average one-year survival rate for d=0 founders, which equals about 90 percent. From row (2) we see that average sales increases by about 7 percent annually from year t-1 to year t+1. As way of comparison, the d=0 founders experience a 9 percent yearly sales growth from year 4 to year 6 (see Table 3). On profitability, OROA increases by 3 percentage points from year t-1 to year t+1, but the difference is not statistically significant. The industry-adjusted change in OROA (not reported) is almost identical.

To evaluate the changes in firm performance around the founder death event against a tighter benchmark, I construct a control group of firms where the founder does not die by matching on first-year firm and characteristics. Appendix A describes how the control group was constructed and gives some summary statistics. I then calculate the mean change between year t-1 and year t+1 for the control group and compare it with the corresponding difference for the d=1 group. These results appear in the last column, where a positive value for Δ means that the d=1 group has a greater mean increase than the control group. While none of the negative values of Δ in (2)-(4) are close to being significant, the positive Δ in rows (1) and (5) are quite sizeable, and the increase in OROA being statistically significant. To conclude, the time-series analysis in Table 5 does not suggest stronger adverse effects of founder loss than the cross-sectional analysis in Table 4.

To focus sharper on firms where I expect adverse effect of founder loss to be greatest,

previous year (67 remains). For (1) we lose about 33 individuals from when calculating Mean_{t+1} partly because of lack of survival and partly because year $t+2$ equals year 2007, so that the sample size is 72.

I redo the analysis of Table 5, but confine attention to majority founders, i.e., founders with at least 50 percent ownership share.

Table 6: Changes in performance around death event, majority founders

	Mean_{t-1}	Mean_{t+1}	Change	Mean_t	N	Δ
Panel A: d=1						
(1)Survive	0.842	0.923	0.081	0.870	57	0.055
	(0.049)	(0.043)	(0.069)	(0.050)		(0.056)
(2)Sales (NOK 1000)	5,741	5,720	-21	6,570	34	461
	(5,990)	(5,758)	(1,425)	(7,389)		(1,166)
(3)Employees	6.118	5.559	-0.559	6.706	34	-0.222
	(7.980)	(5.620)	(1.674)	(23.098)		(1.020)
(4)Assets (NOK 1000)	2,416	2,183	-233	2,613	34	-2
	(2,023)	(1,717)	(455)	(2,383)		(450)
(5)OROA	0.089	0.134	0.045	0.122	28	0.102*
	(0.329)	(0.231)	(0.076)	(0.303)		(0.072)

The table reports firm performance in year t-1 and year t+1, where year t is the death year. A positive change in the third column means an increase from year t-1 to year t+1. Standard deviations in parenthesis except in the first row and in the last column, where standard error is reported. *** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level. All using t-tests.

The results of Table 6 are very similar to in Table 5, in that none of the negative values of Δ in (3) or (4) are close to being significant, and the positive Δ on OROA is statistically significant at the 10 percent level.[25] It is interesting to combine the finding of an apparent positive evolution in profitability with the lack of convincing negative effects on sales found both in the cross-sectional and in the within-firm analysis. These findings suggest that the founder loss does not affect firm growth but could temporarily drive costs up in connection with prior illness.

To conclude, the time-series analysis does not suggest stronger adverse effects of founder loss than the cross-sectional analysis in Table 4. As a check of the robustness of these results, I calculated industry-adjusted change in OROA, and extended the window to including two year before and two years after the death event. The results on Δ were

[25] The number of observations is reduced compared to Table 1b for the same reasons as in Table 5, see footnote 24.

very similar in both Table 5 and Table 6.

One reason for why the within-firm effects of founder loss seem even less pervasive than the results of the cross-sectional analysis could be that founder death is often preceded by illness that makes the firm underperform in the years prior to founder death. Importantly, it is unlikely that the underperformance is of any serious magnitude, as it should in that case be much more visible in the cross-sectional analysis (Appendix B provides a cross-sectional analysis for majority founders). I therefore conclude that the adverse performance effects of founder loss are surprisingly slight.

Seven firms in the sample, six of them from the IT industry, had gone public before the end of 2006. Although this group of companies is small, it is still some interest because of their large value creation.[26] In two of these seven firms, at least one founder died before 2006. The average IPO value of the five d=0 companies were NOK 393 million, and the average IPO value of the two d=1 IPOs were NOK 652 million.[27]

6 Break-down on founder and start-up characteristics

To study whether the loss of a founder can have heterogenous effects, I now expand (1) by adding interaction terms between d and founder and firm characteristics. The interaction terms are split into founder and firm variables. The founder variables are human capital (as measured by previous income), previous wealth, and ownership share (dummies for minority founder, majority founder, and sole founder). The firm variables

[26] The seven are (IPO year and IPO value in million NOK in paranthesis): Active ISP (2004, 215), Axxessit (2004, 382), Customax Intellinet (2000, 523), Funcom Oslo (2005, 421), Intellinet (2000, 268), International Maritime Exchange (2005, 536), and Opera Software (2004, 923). The total IPO value is NOK 3.27 billion.

[27] Both of the d=1 IPOs went public in 2004 or 2005. One of the d=1 founders deceased two years after the IPO and the other d=1 founder deceased four years before the IPO.

are size (capitalization at the start-up date), firm age at the death of the founder, and a dummy that equals one if the firm is in the IT industry. The following table focuses on the six-year horizon. The results for the four-year horizon are similar.

Table 7: Performance regressions with interaction terms, all founders

	Dependent variable								
	Panel A: Survival			Panel B: Sales			Panel C: OROA		
Interaction term	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Founder variables:									
d	-0.446		-0.153	-1.659	0.807	1.209	0.069	-0.271	-0.175
	(0.590)		(0.952)	(3.397)	(2.006)	(3.274)	(0.431)	(0.327)	(0.463)
d*(Log wage)	0.064		0.081	0.114		-0.031	0.001		0.010
	(0.082)		(0.086)	(0.339)		(0.382)	(0.043)		(0.051)
d*(Log wealth)	-0.034		-0.050	0.017		0.013	-0.005		-0.013
	(0.034)		(0.035)	(0.114)		(0.124)	(0.021)		(0.019)
d*(Majority)	0.163		0.170*	0.169		0.196	-0.049		-0.039
	(0.077)		(0.078)	(0.336)		(0.352)	(0.061)		(0.061)
d*(Sole founder)	-0.004		-0.016	0.019		-0.096	-0.097*		-0.090*
	(0.109)		(0.109)	(0.431)		(0.441)	(0.053)		(0.051)
Firm variables:									
d*(Log equity)		-0.023	-0.015		-0.53	-0.074		0.024	0.023
		(0.051)	0.054		(0.169)	(0.192)		(0.029)	(0.033)
d*(Firm age)		-0.027	-0.030*		-0.025	-0.020		-0.002	-0.003
		(0.015)	(0.015)		(0.054)	(0.055)		(0.011)	(0.010)
d*IT		-0.057	-0.098		-0.362	-0.307		-0.037	-0.044
		(0.099)	(0.104)		(0.497)	(0.491)		(0.086)	(0.086)
R^2	0.02	0.02	0.02	0.08	0.11	0.13	0,02	0.02	0.03
N	8,034	8,134	8,034	6,598	6,670	6,598	24,352	24,631	24,352

The table reports estimates of the interaction effect between founder death and other variables in explaining survival (Panel A), log sales (Panel B) and OROA (Panel C). The dependent variable is evaluated after six years, except for in Panel C where performance is evaluated from the second until the sixth year. "Majority" is a dummy that equals one if the founder has at least 50 percent and less than 100 percent ownership in the firm, and "Sole founder" is a dummy that equals one if the founder has 100 percent ownership in the firm. IT is a dummy that equals one if the firm is in the IT industry (NACE 72). In each regression, the corresponding non-interacted variables are included as controls. In (1), (4) and (7) founder variables (age, age squared, gender, years of education) are included as extra controls. In (2), (5) and (8) firm variables (two-digit industry code and start-up year) are included as extra controls. In (3), (6) and (9) both the founder and the firm variables are included as extra controls. In the OROA regressions (7)-(9), firm age dummies are included. The estimation method is probit in (1)-(3) and ordinary least squares in (4)-(9). The reported coefficients in (1)-(3) is the marginal effect evaluated at the mean of the other variables. Robust standard errors clustered at firm level in parenthesis. NOK

10,000 are added to previous income, previous wealth, assets and sales before taking logs. *** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level

The table reports the estimated coefficients for the effect interaction between founder loss and founder variables, in column (1)-(3), on firm variables in columns (4)-(6), and on both founder and firm variables in column (7)-(9). A negative coefficient indicates that increases in the variable gives a larger negative effect of founder loss on performance.

Columns (3), (6) and (9) do not suggest any strong interaction between the founder variables and the effect of founder loss. Losing a founder with higher human capital, as measured by previous wages, seems, somewhat surprisingly, to play little role on survival and growth. Losing a wealthier founder has a negative (and non-significant) effect on survival. Consistent with Table 6, losing a majority founder does not have a strong negative effect relative to the omitted founder group (minority founders). While the coefficient on OROA is negative, the positive coefficient on survival is positive and significant at the 10 percent level.

The variable "sole founder" is a dummy that equals one if the firm has only one founder. As expected the coefficient on this variable is negative in both (3), (6) and (9), meaning that the loss of a sole founder has a stronger negative effect on firm performance than for the omitted group (losing a minority founder): the estimated effect of losing a sole founder for firm six-year survival is less than 2 percentage points smaller than for losing a minority founder. Estimated yearly OROA decreases by about 9 percentage points, which is statistically significant at the 10 percent level. The mean OROA on a six-year horizon is 0.058 for the d=1 sole founders and 0.143 for the d=0 sole founders. Thus there seems to be marked negative effects on the firm of the loss of a sole founder, but far from devastating. To verify that our relatively weak results on the adverse effects of the loss of a sole founder is not due to the functional form assumed on the interaction terms, Appendix C performs an independent analysis of sole founders. This analysis gives

stronger negative effects on firm survival of founder loss than in Table 7; the estimated reduced 6-year survival probability for d=1 founders is 13 percentage points (the average 6-year survival rate for companies with sole founders is 61 percent). This confirms the impression from Table 7 that the adverse effects on firm performance for sole founder loss is far from dramatic.[28]

Turning to the firm variables, the variable "firm age" equals firm age when the founder dies. Since a higher firm age at death would mean that the firm is more mature, I would expect the coefficient on this variable to have a positive sign, meaning that the negative effect of founder loss is smaller when the firm age is higher. There seems to be little evidence in support of this hypothesis. While this variable has a mechanic negative effect on survival in (2) and (3), the coefficient on sales in (6) and on profitability in (9) are also negative, although not significant, meaning that the estimated adverse effect of founder loss is larger for older firms. One reason could be that a higher firm age at the time of death is associated with a longer sickness period of the founder, and hence that the adverse effect on performance of founder illness has had longer time to operate.[29]

Since firms that do not survive are not included in the performance regressions (4)-(9), it is of special importance to investigate whether the firms that do not survive are in some sense more important than firms that do survive. For example, it is conceivable that founder loss could have a large effect on relatively large, more ambitious, start-ups but a smaller effect on small start-ups. Table 7 does not give support to this idea, in that

[28] A fascinating account of how one sole founder dealt with the family and work consequences of sudden personal illness is given in a biography (ISBN 9788204117144) written by Maria Thommessen, the founder of dinkost.no, a leading Norwegian internet portal for personal nutrition and health ("dinkost.no" means "yourdiet"). Thommessen, who held a Phd in nutrition, started up dinkost.no in 2000 and deceased in 2006 at age 47. According to www.1881.no, the company grew from NOK 200K in sales in 2000 to NOK 5M in sales in 2006. The number of employees grew from one to five during this period. This company seems to be a good example of a start-up where the founder was essential in spotting the opportunity and doing the initial positioning, but apparently was less crucial after that initial period.

[29] To investigate whether the relation between firm age at death and performance is non-linear, I tried adding a quadratic and cubed term in firm age at death. These regressions did not suggest strong non-linearities.

the coefficient on size on survival is small, and far from statistically significant. Since the data consists of a representative sample of incorporations, most of the firms are small, and a related concern is whether the weak effects of founder loss on the surviving firms are confined to small firms. The estimates in (6) and (9) does not support this idea, in that the estimated interaction terms between founder loss and firm size are small and statistically insignificant.

For the interaction between loss and the firm being in the IT industry, the estimated negative effect on survival and on sales are quite large, but the standard errors are too big for the effects to be statistically significant. The estimated coefficients still hint that founder specificity could be larger in industries with a higher degree of intangible capital.

Finally, I have exposed the results in Table 7 to the same robustness checks as described after Table 4. The results do not change.

7 Conclusion

Models of hold-up problems and asset specificity are central in economics, but much less empirical work has tested the underlying assumptions. The novelty of the present paper is to test an assumption from a large literature on financial frictions and credit constraints; that founders are non-substitutable to new firms.

In order to analyze the importance of founders for nascent firms, I have exploited variation in the occurrence of founder death in a large sample of representative start-ups from Norway. Across a variety of tests, the results consistently point towards small adverse effects of founder death on start-up performance. Although the findings do not imply that founders are fully substitutable, they do suggest that, for representative start-ups, the degree of non-substitutability is surprisingly low.

This finding has implications for both how we view young companies and how we view

the entrepreneur. First, it suggests that founder-specificity at the very least is not the only factor behind credit constraints and inefficient investment levels for young companies. Second, it suggests, as held by Schumpeter (1943), that the most important role for founders is as a discoverer of new opportunities rather than as a manager. Obtaining a better understanding of how ideas are generated and molded into new firms seems like an important area for future research.

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9 Appendix A: Control groups

This appendix describes how the control groups used in Table 5 and in Table 6 were constructed, and provides first-year summary statistics.

The control group used in Table 5 was constructed by first sorting the entire population of founders into groups with the same start-up year, start-up size (NOK 50,000 intervals for equity and 1M intervals for assets) and industry code (IT or not). Subgroups were then

formed based on the founder characteristics age (3-year intervals), previous income (NOK 50,000 intervals), previous wealth (NOK 200,000 intervals), ownership share (majority owner or not) and years of education. For each $d = 1$ founder, I selected the two closest neighbours, excluding neighbours with $d = 1$ and neighbors with a different start-up year. The control group in Table 6 (majority founders) was constructed using the same procedure, except that founders with ownership share less than 50 percent ownership share were deleted before the first step. For both control groups, two matching individuals were obtained for 93 percent of the $d = 1$ founders. The "Difference" columns refers to the difference in means between the d=1 group and the control group. A positive difference means that the mean of the d=1 group is higher.

Table 8: Summary statistics, control groups

			all				majority	
Panel A: Founders	Mean	(St.dev)	Difference	(St. error)	Mean	(St.dev)	Difference	St.error
Age	47.8	(13.0)	6.4***	(1.2)	46.1	(10.9)	7.1***	(1.6)
Years of education	12.1	(2.7)	-0.9***	(0.23)	11.9	(2.5)	-0.4	(0.35)
Fraction male	0.86	(0.35)	0.03	(0.03)	0.85	(0.36)	0.08**	(0.04)
Previous income (1000)	339	(215)	7	(27)	373	(209)	33	(51)
Previous wealth (1000)	1,452	(6,176)	-83	(448)	1,517	(6,621)	455	(826)
Ownership share	0.45	(0.27)	0.04**	(0.03)	0.69	(0.22)	0.06**	(0.03)
N		338				153		
Panel B: Firms, 1st yr								
Year	1998.8	(2.0)	-0.12	(0.19)	1998.7	(2.1)	-0.14	(0.29)
Equity (NOK 1000)	217	(619)	5	(57)	229	(877)	18	(122)
Number of founders	2.8	(1.4)	-0.07	(0.13)	1.8	(0.61)	-0.02	(0.10)
Assets (NOK 1000)	3,471	(16,504)	3	(1,750)	2,596	(5,870)	-593**	(577)
Employees	5.1	(12.4)	-0.19	(1.24)	4.6	(7.5)	-0.47	(1.14)
Leverage ratio	0.79	(0.38)	-0.01	(0.03)	0.81	(0.26)	-0.03	(0.04)
IT	0.26	(0.44)	-0.05	(0.04)	0.27	(0.44)	-0.05	(0.06)
N		338				153		

The table depicts summary statistics for the two control groups considered in Table 5 and in Table 6. Previous income and previous wealth are calculated as means over five years prior to start-up year. Number of founders is the number of founders with at least 10 percent ownership share. Leverage ratio is defined as book value of debt divided by assets. IT is defined as fraction of IT start-ups (NACE 72). Krone values are expressed in 2002 kroners. *** Significant at the 1 % level ** Significant at the 5 %

level * Significant at the 10 % level

10 Appendix B: Majority founders

In this appendix, I redo the cross- analysis of Section 5, but confine attention to majority founders, i.e., founders with at least 50 percent ownership share. From the d=1 group, I exclude individuals that decease later than the seventh year of operations.

Table 8: Performance regressions, majority founders

	Panel A: after 4 years			Panel B: after 6 years		
Dependent variable	λ	R^2	N	λ	R^2	N
(1) Survival	-0.041	0.03	5,036	0.017	0.03	3,448
	(0.067)			(0.076)		
(2) Log employees	0.109	0.13	4,199	0.065	0.11	2,874
	(0.119)			(0.163)		
(3) Log sales	0.173	0.18	4,199	0.057	0.13	2,874
	(0.188)			(0.254)		
(4) Log assets	0.088	0.21	4,199	0.086	0.17	2,874
	(0.158)			(0.184)		
(5) OROA (year 2-)	-0.025	0.05	10,747	-0.024	0.05	10,715
	(0.035)			(0.033)		

Each row in Panel A (B) gives the estimation results for a separate regression where the dependent variable is given in the first column in the table. The first column in Panel A (B) is the estimated λ in each regression, i.e., the effect of majority founder death on the dependent variable. In Panel A (B), the dependent variable is evaluated after four (six) years, except for in row (5) where performance is evaluated in the second until the fourth (sixth) year. Founder variables (age, age squared, gender, years of education, log previous income, and log previous wealth), firm variables (log equity, two-digit industry code), and start-up year are included as controls in (1)-(4). In (5), firm age dummies are included as controls. The estimation method is ordinary least squares in (2)-(5) and probit in (1). In (1), the marginal effect is reported. Robust standard errors clustered at firm level in parenthesis. NOK 10,000 are added to previous income, previous wealth, assets and sales before taking logs.*** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level

In the first four rows of Panel A, I regress measures of firm performance after four years on the explanatory variables, and in the last row I use each individual-year. As for the regressions in Table 4, neither the size nor the significance level of the estimated coefficient suggest a strong adverse effect of founder death. The only coefficient that suggests an

economic effect of some magnitude is the coefficient on survival. This estimate suggest that firms where of d=1 founders have about 4 percentage points lower four-year survival probability than firms of d=0 founders. Given that the four-year survival rate for firms where the founder stays alive is about 70 percent, the estimated difference does not appear large. Panel B shows that the results on six-year performance are very similar to four-year performance, except that here the firms of the d=1 founders perform slightly better with respect to survival than the firms of the d=1 founders. Both on a four-year and on a six-year horizon, the firms with the d=1 founders have about 2.5 percentage points lower yearly OROA, a difference that is not statistically significant.

11 Appendix C: Sole founders

This appendix provides cross-sectional analysis and panel analysis for sole founders. The number of d=1 sole founders is 35.

Table 9: Performance regressions, sole founders

	Panel A: after 4 years			Panel B: after 6 years		
Dependent variable	λ	R^2	N	λ	R^2	N
(1) Survival	-0.185**	0.06	1,617	-0.132	0.06	1,|02
	(0.097)			(0.105)		
(2) Log employees	-0.030	0.14	1,381	0.031	0.14	948
	(0.180)			(0.226)		
(3) Log sales	0.114	0.21	1,381	-0.103	0.18	948
	(0.304)			(0.493)		
(4) Log assets	0.028	0.26	1,381	0.097	0.23	948
	(0.231)			(0.249)		
(5) OROA (year 2-)	-0.066*	0.05	3,515	-0.065*	0.07	3,455
	(0.037)			(0.034)		

Each row in Panel A (B) gives the estimation results for a separate regression where the dependent variable is given in the first column in the table. The first column in Panel A(B) is the estimated λ in each regression, i.e., the effect of sole founder death on the dependent variable. In Panel A (B), the dependent variable is evaluated after four (six) years, except for in row (5) where performance is evaluated in the second until the fourth (sixth) year. Founder variables (age, age squared, gender, years of education, log previous income, and log previous wealth), firm variables (log equity, two-digit industry code), and

start-up year are included as controls in (1)-(4). In (5), firm age dummies are included as controls. The estimation method is ordinary least squares in (2)-(5) and probit in (1). In (1), the marginal effect is reported. Robust standard errors clustered at firm level in parenthesis. NOK 10,000 are added to previous income, previous wealth, assets and sales before taking logs.*** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level

Table 10: Changes in firm around death event, sole founders

	Mean_{t-1}	Mean_{t+1}	Change	Mean_t	N	Δ
Performance variable						
(1)Survive	0.810	0.867	0.057	0.875	21	0,077*
	(0.088)	(0.091)	(0.129)	(0.085)		(0.040)
(2)Sales (in NOK 1000)	7,600	8,744	264	8,744	12	-680
	(8,638)	(10,192)	(3,478)	(10,192)		(795)
(3)Employees	7.000	5.750	-1.250	8.083	12	-0.715
	(6.941)	(4.945)	(2.387)	(8.712)		(1.725)
(4)Assets (in NOK 1000)	2,465	2,255	-210	2,507	12	-845**
	(2,178)	(1,737)	(804)	(2,181)		(464)
(5)OROA	-0.071	0.123	0.194*	0.056	10	0.184
	(0.146)	(0.240)	(0.137)	(0.212)		(0.161)

The table reports firm performance in year t-1 and year t+1, where year t is the death year, restricting attention to sole founders. A positive change in the third column means an increase from year t-1 to year t+1. Standard deviations in parenthesis except in the last column where standard error is reported.. *** Significant at the 1 % level ** Significant at the 5 % level * Significant at the 10 % level. All using t-tests.