Spin-offs: Theory and Evidence

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Abstract

We develop a "passive learning" model of firm entry by spin-off: firm employees leave their employer and create a new firm when (a) they learn they are good entrepreneurs (type I spin-offs) or (b) they learn their employer's prospects are bad (type II spin-offs). Our theory predicts a high correlation between spin-offs and parent exit, especially when the parent is a low-productivity firm. This correlation may corresponds to two types of causality: spin-off causes firm exit (type I spin-offs) and firm exit causes spin-off (type II spin-offs). We test and confirm this and other model predictions on a unique data set of the U.S. automobile industry. Finally, we discuss policy implications regarding "covenant not to compete" laws.

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1 Introduction

In many industries, a considerable fraction of firm entry results from spin-offs. For example, in the automobile industry and in the period 1895–1969, 18% of all new firms were spin-offs of existing firms. This pattern suggests at least two questions: First, why do spin-offs take place? and second, do spin-offs lead to a socially efficient allocation of resources?

Recent research provides a series of answers to the first question. Klepper and Slepper (2002) and Klepper and Thompson (2005, 2006) propose a "disagreement" theory of spin-offs. If an employee's idea is not adopted by his employer, then the employee is likely to leave and create a firm where his idea can be implemented. Chatterjee and Rossi-Hansberg (2007) propose an adverse selection theory of spin-offs. To the extent that employees have better information about the value of their ideas, an adverse selection problem arises, the equilibrium of which is for owners of better ideas to start a new firm.[1] Franco and Filson (2006) stress the fact that employees acquire know-how while working for a firm and eventually capitalize on that know-how by starting their own firm.

Regarding the welfare impact of spin-offs, there are two important considerations. To the extent that exiting employees take ideas or other resources from their former employer, spin-offs may imply an equilibrium with under-investment, as firms are reluctant to invest in ideas that will be stolen by their employees. By contrast, to the extent that employees increase their human capital while employed and then apply it to the creation of new value, spin-offs correspond to an efficient reallocation of resources. The relative magnitude of these two effects is an important policy question. Some states enforce "covenant not to compete" (CNC) laws on the basis that the first effect dominates. However, authors such as Franco and Mitchell (forthcom-

1. Baccara and Razin (2006) develop a theory of rent distribution within the firm that relates to the work of Klepper and Thompson (2005, 2006) and Chatterjee and Rossi-Hansberg (2007). To the extent that the introduction of new ideas entails a reshuffling of rents within the firm, Baccara and Razin (2006) provide an alternative "spin-off" theory based on the reciprocal relation between innovation and the firm's governance structure. Their theory implies that employees choose to spin-off either because they fear the employer may expropriate the rents flowing from innovation or because the employer discourages innovation in favor of maintaining the existing intra-firm rent distribution.

ing) argue that CNC laws in Massachusetts may have caused Route 128 to be taken over by the Silicon Valley, suggesting that the value creation effect of spin-offs may be important.

In this paper, we present a novel theory of spin-offs. Our model implicitly or explicitly incorporates many of the features of previous models. However, we extend the analysis in two important dimensions. First, in the tradition of Jovanovic's (1982) "passive learning" theory, we assume that not only firms learn about their type over time but also that employees learn their abilities over time. In this context, spin-offs take place either because an employee learns that he would make a good entrepreneur (type I spin-off) or because he learns his employer's prospects are poor, and so the opportunity cost of leaving the firm is small (type II spin-off).

The second important contribution of our work is that, unlike the previous literature, we pay close attention to the interdependence between parent performance and spin-off performance as implied by our model. First, we show that spin-off entrants are more likely to survive than de novo entrants (because the group of spin-off entrants is biased toward high types). Second, we show that spin-offs have a negative impact on the survival of low-type parents (because a spin-off implies that the parent loses talent which is better than market average). Third, we show that spin-offs originating in surviving parents perform worse than spin-offs originating in dying parents (because the latter include a mixture of high type and low type entrepreneurs). In sum, we show that sometimes spin-offs cause parent failure, whereas in other cases parent failure causes spin-offs.

We test these predictions on a dataset of the automobile industry. We show that all of our predictions are economically and statistically significant. Finally, we discuss policy implications, especially with regard to "covenant not to compete" (CNC) laws.

2 Model

Consider a homogeneous product industry with demand $D(p)$ and inverse demand $P(Y)$, where p is price and Y industry output. We impose fairly weak restrictions on the market demand function:

Assumption 1 $\lim_{Y \to 0} P(Y) = \infty; \quad \lim_{p \to 0} D(p) = \infty.$

Market output Y is supplied by a large number of firms, which can be of different types. Specifically, a type z firm produces y_z. If we let μ_z be the measure of such firms, industry output is then given by

$$Y = \sum \mu_z \, y_z$$

A firm is made up of two agents: a manager (also referred to as the "entrepreneur"), and an employee (also referred to as "worker"). Each agent can be of two types: H (probability α at birth) and L (probability $1 - \alpha$). A type z firm has profit

$$\pi_z = p \, y_z - \omega$$

where y_z is output level and ω the wage rate paid to the sole worker. Output in turn is given by

$$y_z = m^\sigma \, w^{1-\sigma}$$

where $m = H, L$ is the manager's type, $w = H, L$ the worker's type, and σ a parameter.

We make two assumptions regarding the production function.

Assumption 2 $\sigma > \frac{1}{2}$

Notice that, together with $H > L$, Assumption 2 implies that

$$\begin{aligned} y_{HH} > y_{HL} > y_{LH} > y_{LL} \\ \pi_{HH} > \pi_{HL} > \pi_{LH} > \pi_{LL} \end{aligned} \tag{1}$$

where $z = HH, HL, LH, LL$ represents the four possible types a firm can be: the first subscript denotes the manager's type and the second superscript denotes the worker's type.

We additionally make the following assumption

Assumption 3 $y_{LL} < \omega < \rho \, (1 - \alpha) \, y_{LL} + \big(1 - \rho \, (1 - \alpha)\big) \, y_{LH}$

Notice that the right-hand side is a convex combination of y_{LL} and y_{LH}. Since, from (1), $y_{LH} > y_{LL}$, there exists a non-empty set of values of ω satisfying Assumption 3.

Time is discrete and continues on forever. The sequence of events in each period is as follows. At the beginning of the period, each manager, knowing its firm's type, decides whether to remain active or to exit. Regardless of the manager's decision, a firm may die for exogenous reasons. Some of these exogenous shocks are unexpected, some are anticipated by one period (anticipated both by the manager and by the worker). Let $1-\beta$ be the probability of an unexpected shock leading to immediate exit and $1-\gamma$ is the probability of an anticipated shock. In each period, the fraction of firms that survive (even after voluntary exit decisions take place) is given by $\beta\,\gamma$.

After exits have taken place (voluntary and involuntary exits), potential entrants (entrepreneurs) decide whether to enter. Potential entrants do not know their type or the type of the worker they hire upon entry. Once the firm becomes active, both manager and employee discover their type (and thus the firm's type as well).

The above process of entry and exit leads to a measure of active firms during the period. Each firm's worker now decides whether to continue as a worker or to try out as an entrepreneur. Trying out as an entrepreneur is a lottery that costs c. With probability ρ, the worker indeed successfully founds a new firm; with probability $1-\rho$ the attempt fails, in which case the agent continues as worker. If the worker leaves the firm (i.e., it draws the lottery and is successful at it), then the firm hires a new worker. New workers are undifferentiated and only learn their type the period after they join a firm.

Finally, firm profits are received for the period. The payoffs for each agent are as follows: the worker receives a market wage of ω; the manager, in turn, receives firm profits minus the wage paid to the worker.

Figure 1 shows the various flows that take place in the model. Squares represent the four possible types of firms. Circles represent the three transitional channels: entry, spin-off and exit. The values adjacent to each arrow represent the measure of firms per unit measure in the initial box or circle. So for example the left-most arrow indicates that, per each unit measure of HH firms, $(1-\beta)\,(1-\gamma)$ transfer to the exit bin. Notice that these values represent measures, not probabilities. In particular, the total sum of outgoing arrows need not equal 1. For example, a measure one of surviving HH firms leads to a measure one of HH firms grater than one, the difference

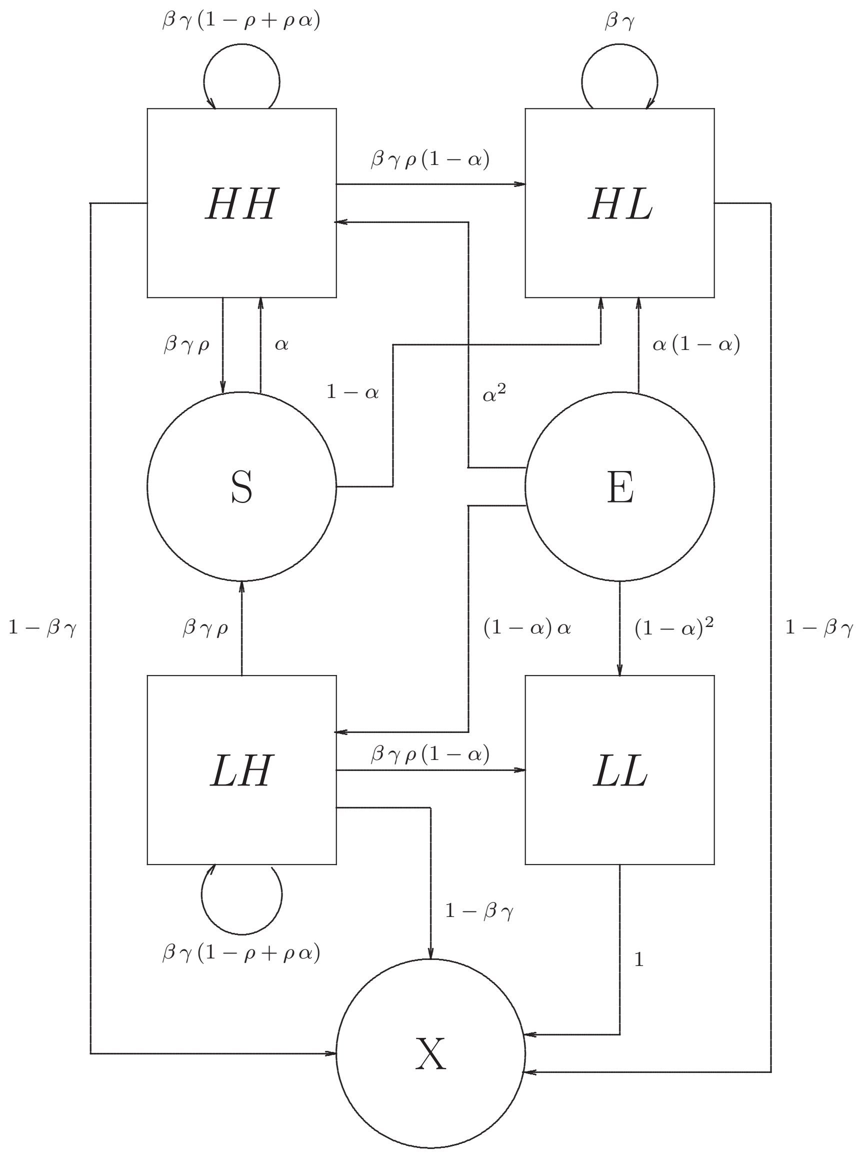

Figure 1: Entry, mobility, spin-off, and exit flows.

being accounted by spin-offs.

Numerically, let μ_z^t be the measure of type z firms at the beginning of period t. Then the transition equations are as follows:

$$\begin{aligned}
\mu_{HH}^{t+1} &= \beta\,\gamma\,\big(1-\rho+\rho\,\alpha\big)\,\mu_{HH}^t + \nu\,\alpha^2 \\
\mu_{HL}^{t+1} &= \beta\,\gamma\,\mu_{HL} + \beta\,\gamma\,\rho\,(1-\alpha)\,\mu_{HH}^t + \nu\,\alpha\,(1-\alpha) \\
\mu_{LH}^{t+1} &= \beta\,\gamma\,\big(1-\rho+\rho\,\alpha\big)\,\mu_{LH}^t + \nu\,(1-\alpha)\,\alpha \\
\mu_{LL}^{t+1} &= \beta\,\gamma\,\rho\,(1-\alpha)\,\mu_{LH}^t + \nu\,(1-\alpha)^2
\end{aligned} \tag{2}$$

where ν is the measure of de novo entrants. Consider the first transition equation, that for μ_{HH}. The first term on the right-hand side corresponds to firms who were of type HH in the previous period. In order for them to be counted as HH in period $t+1$ several consideration must be taken into account. First, it must be that they do not die (which happens with probability $\beta\,\gamma$). Next, with probability ρ the firm's worker will successfully start a new firm. If that happens, the parent firm hires a new worker who, with probability α, is also of type H. So, the firm retains its HH status with probability $1-\rho$ (no spin-off) plus $\rho\,\alpha$ (spin-off and hight type replacement worker). Finally, the second term in the right-hand side corresponds to de novo entry: with probability α^2, both manager and worker are of type H. The remaining transition equations have a similar structure. The only difference to note is that, for types HL and LL, one additional source is given formerly type HH and LH firms, respectively, when their H worker is replaced by an L worker.

3 Equilibrium

We now look for a situation where the values of μ_z are stable. Specifically, a stationary equilibrium is defined by a set of measures μ_z, ν, and an industry price p that satisfy a series of transition and optimality conditions:

1. The system of transition equations (2) holds;
2. Managers make optimal exit decisions given firm type z;
3. Workers make optimal spin-off decisions;

4. Potential entrants make optimal entry decisions.
5. The market clears: $p = P(Y)$, where $Y = \sum y_z$.

Our main result pertains to the existence, uniqueness and properties of such an equilibrium.

Proposition 1 (stationary equilibrium) *There exists a unique stationary equilibrium. In equilibrium,*

(a) Firms choose to voluntarily exit if and only if their type is $z = LL$;

(b) Workers attempt a spin-off if and only if their type is H or their type is L and they know the firm will exit.

The proof may be found in the Appendix (to be completed).

Part (b) of Proposition 1 includes two different types of spin-off. A worker who learns she is of type H is strictly better off by spinning-off, regardless of the parent's type; we call this a type I spin-off. Moreover, a worker who learns that the firm will exit in the next period is also strictly better off by spinning-off, regardless of its type; we call this a type II spin-off.

4 Testable implications

We now explore some implications of our model for the relation between spin-offs and firm performance. Given data availability, we consider an indirect measure of firm performance: survival rates. We are interested in the impact of spin-offs on the parent's and the new firm's survival.

Proposition 2 (spin-off performance)

(a) Spin-offs originating in surviving parents survive with higher probability than de novo entrants.

(b) Spin-offs originating in surviving parents survive with higher probability than spin-offs originating in non-surviving parents.

(c) The survival rates of a spin-off originating in a surviving parent is independent of parent type.

Proof: A de novo entrant's manager is of type H with probability α; the manager of a spin-off firm originating in a surviving parent is of type H with probability 1 (regardless of parent type); and the manager of a spin-off firm originating in a non-surviving parent is of type H is probability strictly lower than 1. The various results follow. ■

Proposition 3 (parent performance)

(a) *If a firm's manager is of type H, then its survival rate is invariant with respect to the occurrence of a spin-off.*

(b) *If a firm's manager is of type L, then its survival rate is lower conditional on giving birth to a spin-off.*

(c) *A firm's survival rate conditional on giving birth to a low performance spin-off is lower than its survival rate conditional on giving birth to a high performance spin-off.*

Proof: A firm with an H type manager will switch between type $z = HH$ and $z = HL$. Whichever is the case, the firm does not voluntarily exit. (Recall that with probability $1 - \beta\gamma$ the firm exits dues to an exegenous shock.) Therefore, while losing an H type worker decreases the firm's value, it does not change its survival probability. A firm with a type L manager who loses a type H worker switches from $z = LH$ to $z = LL$ with probability $\rho(1 - \alpha)$, in which case it exits. Otherwise, it remains at $z = LH$, in which case it does not voluntarily exit. Finally, an L manager firm that is subject to an anticipated exit-inducing shock will see its worker attempt a spinoff, regardless of worker type, which in turn leads to a lower performance spinoff. By contrast, the same firm when not subject to an anticipated exit-inducing shock will only give birth to high-performance spin-offs. A firm with an H manager always gives rise to high performance spin-offs, so the above statement can be made without conditioning on the parent's manager type. ■

5 Data and empirical results

We test the implications of our model using a unique dataset of the U.S. automobile industry. The dataset covers U.S. companies that sold at least one automobile to the public during the industry's first 75 years (1895–1969), a total of 780 firms.

The data sources come from different industry references. First, Smith (1968) provides a list of every make of automobile produced commercially in the U.S. from the industry's beginnings in 1895 through 1969.[2] The book lists the firm that manufactured each car make, the firm's location, the years the particular make was produced, and any reorganizations and ownership changes the firm underwent. Smith's list of car makes was then used to derive the entry and exit of each individual firm, where entry and exit dates are based on the first and last year of commercial production. As shown in Figure 2, the automobile industry went through a tremendous development during this period, evolving from a small infant industry into a gigantic, concentrated, mature industry. The number of automobile manufacturers peaked at 206 in 1908. From then and until the late 1920s there was a considerable industry shakeout, with the total number of firms dropping to 24 in 1929. Further consolidation took place, and by 1940 there were only 8 active firms. As happens in many other industries (e.g., Dunne et al, 1988) the net entry/exit rate is much lower than the turnover rate, that is, we observe simultaneous entry and exit in the industry.

Second, Kimes (1996) provides comprehensive historical information for every automobile make produced in the U.S. from 1890–1942. Using Kimes (1996), we are able to collect additional biographical information about the entrepreneurs who founded and ran each individual firm. An entrepreneur was then categorized into the following groups. One group includes those entrepreneurs who had prior experience in engineering, mechanics or other technologically related industries. Another group includes experienced entrepreneurs who founded and ran firms before entering the automobile industry. Still another group includes spin-off entrepreneurs, that is, entrepreneurs who worked as employees in existing automobile firms before starting their

2. The original book published in 1968 was updated to include information up to 1969.

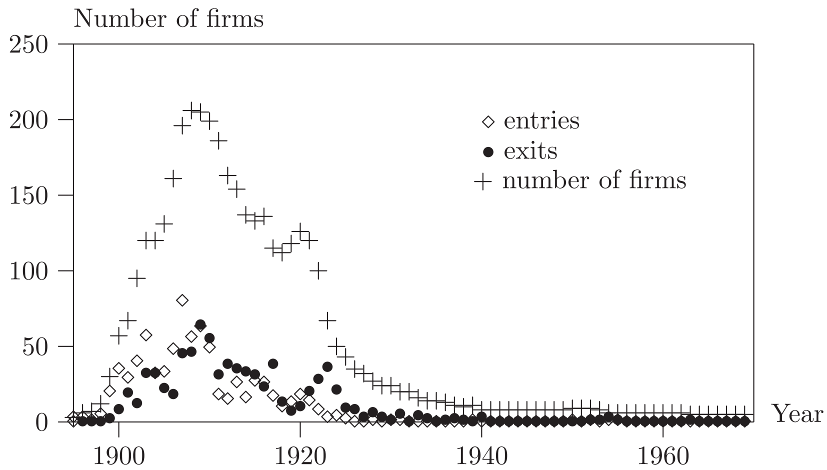

Figure 2: Evolution of the U.S. automobile industry, 1895–1969.

own firm. The last group consists of de novo entrepreneurs, namely those with no identifiable background. Note that these groups are not mutually exclusive: for example, someone might have run a non-automobile firm and also worked as an employee in an automobile firm before starting his own automobile company. In that case, he is categorized as both an experienced entrepreneur and a spin-off. Figure 3 splits the number of entries into de novo entries and entry by spin-off. (We restrict to the period 1895–1925, when the number of entrants was significant.) As can be seen, after the first industry shakeout (circa 1910), the number of de novo entrants and entrants by spin-off is of the same order of magnitude.

Third, Bailey (1971) provides a list of leading automobile makes from 1896–1970 based on top-15 annual sales. Using this information, together with the other two sources, we are able to identify top automobile producers during the relevant periods.

In summary, we put together a dataset including the following information:

1. The entry year of each firm;
2. The exit year of each firm;
3. The type of each firm exit;

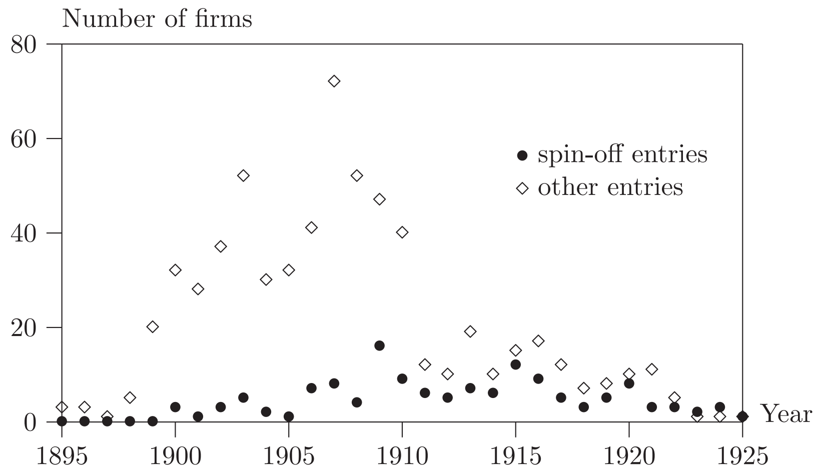

Figure 3: Evolution of the U.S. automobile industry, 1895–1925.

4. The background of each entrepreneur mapped into four categories, including spin-offs, de novo entrants, entrepreneurs with technological background and experienced entrepreneurs;
5. The quality of each firm in terms of producing top makes in the industry or not;
6. The firm's location.

Using the above information, we created the following dummy variables (indexed by firm and year). Whenever the definition of the variable is not obvious, an explanation is given.

- *Firm died in current period.*
- *Firm is Top.* The firm was classified as the producer of a top car make during at least one year in the sample.
- *Firm is Bottom.* The firm is not a Top firm.
- *Firm was created as a spin-off.* The firm's founder worked for another auto manufacturer prior to founding the firm.
- *Firm was spun-off from Top parent.*
- *Firm was spun-off from Bottom parent.*

- *Firm was spun-off from Bottom surviving parent.* A surviving parent is defined as one that was active for at least 2 years after the spin-off took place.
- *Firm was spun-off from Bottom non-surviving parent.*
- *Firm is Top and gave birth to spin-off.*
- *Firm is Bottom and gave birth to spin-off.*
- *Firm is Bottom and gave birth to Good spin-off.* A Good spin-off is defined as one that survives for more than 1 year.
- *Firm is Bottom and gave birth to Bad spin-off.* A Bad spin-off is defined as one that survives for only 1 year.
- *Founder's background is technology related.*
- *Founder's background is entrepreneurial related.*

In addition, we created the following variables:

- *Firm age.*
- *Year.*
- *Region.* We created seven regional dummies corresponding to: Great Lakes, Mid Atlantic, Michigan, Mid West, New England, South, and West).

■ **Descriptive statistics.** Tables 1 and 2 provide some descriptive statistics of the main variables we created, both at the firm level and at the firm × year level. From Table 1 (firm level data), we can see that about 17.7% of all firm entries took place as spin-offs from existing firms (6.8% from Top parents, 8.1% from Bottom surviving parents, and 2.7% from Bottom non-surviving parents). About 6% of firms are Top. Almost one half of firm founders had a technology related background; more than a third had founded a firm previously.

From Table 2, we can see that the firm death rate is about 17.2% per year. This is somewhat higher than a typical exit rate in mature industries (e.g., Dunne et al, 1988), which is only normal given that we are analyzing

Table 1: Descriptive statistics (firm level data).

Variable	Mean	Std Dev	Min	Max
Firm was created as a spin-off	0.177	0.382	0	1
Firm was spun-off from Top parent	0.068	0.252	0	1
Firm was spun-off from Bottom parent	0.108	0.311	0	1
Firm was spun-off from Bottom surviving parent	0.081	0.273	0	1
Firm was spun-off from Bottom non-surviving parent	0.027	0.162	0	1
Firm is Top	0.061	0.239	0	1
Founder's background is technology related	0.466	0.499	0	1
Founder's background is entrepreneurial related	0.375	0.484	0	1
Entry year	1908	6.3	1895	1939
Number of observations: 776				

Table 2: Descriptive statistics (firm×year level data).

Variable	Mean	Std Dev	Min	Max
Firm died in current period	0.172	0.377	0	1
Firm was created as a spin-off	0.197	0.397	0	1
Firm was spun-off from Top parent	0.098	0.298	0	1
Firm was spun-off from Bottom parent	0.098	0.298	0	1
Firm was spun-off from Bottom surviving parent	0.076	0.265	0	1
Firm was spun-off from Bottom non-surviving parent	0.022	0.147	0	1
Firm is Top	0.198	0.399	0	1
Firm is Top and gave birth to spin-off	0.010	0.100	0	1
Firm is Bottom and gave birth to spin-off	0.010	0.099	0	1
Firm is Bottom and gave birth to Good spin-off	0.007	0.086	0	1
Firm is Bottom and gave birth to Bad spin-off	0.002	0.050	0	1
Founder's background is technology related	0.536	0.499	0	1
Founder's background is entrepreneurial related	0.450	0.498	0	1
Firm age	6.847	7.176	1	43
Year	1913	8.4	1895	1942
Number of observations: 4472				

a growing industry, where the level of turnover is typically higher. We also see that the average age of a firm is just under 7 years.

■ **Regressions.** We ran a series of logit regressions using firm-year observations with firm death as the dependent variable. The data range is from 1895–1942, including 776 firms and 4472 firm-year observations.[3] In each regression, we divide the set of explanatory variables into two sets. The first set corresponds to the variables that have a direct bearing on the testable implication included in Propositions 2 and 3. The second set corresponds to variables that we would expect to have an influence of firm survival. We could have developed a more complex theoretical model to account for those effects but chose rather to stick to the main focus in the paper: the relation between parent and spin-off performance.

Table 3 presents results from our first regression. In this regression, we consider three variables that address the implications of Propositions 2 and 3. Part (a) of Proposition 2 suggests that the coefficient of the variable *Firm was created as a spin-off* should be negative.[4] The second and third explanatory variables directly test parts (a) and (b) Proposition 3. Specifically, we expect the coefficient of *Firm is Top and gave birth to spin-off* to be zero and the coefficient of *Firm is Bottom and gave birth to spin-off* to be positive: when a small firm gives birth to a spin-off, it loses valuable talent, and this in turn increases the probability that it will exit. In other words, a *depletion effect* takes place.

The results are broadly consistent with these predictions. The coefficient of *Firm was created as a spin-off* is negative and significant at the 6.4% level. The coefficient of *Firm is Top and gave birth to spin-off* is not significantly different from zero. Finally, the coefficient of *Firm is Bottom and gave birth to spin-off* is positive and significant at the one percent level.

In order to get a feel for the economic magnitude of these coefficients,

3. Given the information provided in Kimes (1996), we collect biographical information about the entrepreneurs up to 1942, before the U.S. entered WWII.

4. Strictly speaking, part (a) of Proposition 2 states that spin-offs *of surviving parents* perform better than de novo entrants. Spin-offs originating in non-surviving firms are also started by type L entrepreneurs. Insofar as the mixture of L and H types in this instance is not too biased towards L types, then part (a) of Proposition 2 can also be read unconditionally on parent's survival.

Table 3: Spin-off and parent performance.

Dependent variable: *Firm died in current period*				
Explanatory variables	Coef.	Std. Err.	z	$P > \|z\|$
Firm was created as a spin-off	−0.239	0.129	−1.85	0.064
Firm is Top and gave birth to spin-off	−0.105	1.035	−0.10	0.919
Firm is Bottom and gave birth to spin-off	0.818	0.319	2.56	0.010
Firm is Top	−2.100	0.228	−9.20	0.000
Founder's background is technology related	−0.320	0.097	−3.31	0.001
Founder's background is entrepreneurial related	−0.267	0.089	−2.99	0.003
Firm age	−0.015	0.010	−1.59	0.111
Year	0.021	0.007	2.97	0.003
Constant	−41.000	13.428	−3.05	0.002
Number of observations: 4458				

we also computed their associated odds ratios. The odds ratio for *Firm was created as a spin-off* is given by .7877. This implies that the ratio $d/(1-d)$, where d is the death rate, is $(1-0.7877)$ lower for spinoff firms. Specifically, given that the average death rate of a non-spinoff firm is 17.64%, our model predicts that the average death rate of a spin-off firm is 14.44% (in other words, the death rate drops by 18%). (The average death rate of spin-offs in our sample is 15.14%.) The odds ratio of *Firm is Bottom and gave birth to spin-off* is is given by 2.2652. This implies that the ratio $d/(1-d)$ is $(2.2652-1)$ higher for Bottom firms who give birth to spinoff firms than for other Bottom firms. Specifically, given that the average death rate of a Bottom firms who do not give birth is 20.13%, our model predicts that the average death rate of a Bottom firm who gives birth to a spin-off is 36.34% (in other words, the death rate increases by 81%). (The sample average death rate of Bottom firms who give birth is 36.36%.)

The remaining explanatory variables have the signs we would expect. Many models of firm entry and exit predict that larger and/or more profitable firms survive with higher probability. We thus expect a negative coefficient for *Firm is Top*, as the results indeed suggests. Any model with experience effects would predict a positive coefficient for the variables *Founder's background is technology related* and *Founder's background is entrepreneurial related*. Again, the results confirm the expectation.

Table 4 reports on the results of a second regression. We now "split" the variable *Firm was created as a spin-off* into three variables: *Firm was spun-off from Top parent*, *Firm was spun-off from Bottom surviving parent*, and *Firm was spun-off from Bottom non-surviving parent*. Part (b) of Proposition 2 implies that the coefficient of *Firm was spun-off from Bottom non-surviving parent* be greater than the coefficient of *Firm was spun-off from Bottom surviving parent*. Part (c) of Proposition 2 implies that the coefficient of *Firm was spun-off from Top parent* and *Firm was spun-off from Bottom surviving parent* be the same.

The results are again broadly consistent with the theory. Both the coefficients of *Firm was spun-off from Top parent* and *Firm was spun-off from Bottom surviving parent* are negative and significantly different from zero

Table 4: Spin-off and parent performance.

Dependent variable: *Firm died in current period*				
Explanatory variables	Coef.	Std. Err.	z	$P > \|z\|$
Firm was spun-off from Top parent	−0.295	0.191	−1.54	0.123
Firm was spun-off from Bottom surviving parent	−0.254	0.162	−1.56	0.118
Firm was spun-off from Bottom non-surviving parent	−0.062	0.264	−0.24	0.813
Firm is Top and gave birth to spin-off	−0.101	1.035	−0.10	0.922
Firm is Bottom and gave birth to spin-off	0.825	0.319	2.59	0.010
Firm is Top	−2.086	0.231	−9.01	0.000
Founder's background is technology related	−0.321	0.097	−3.32	0.001
Founder's background is entrepreneurial related	−0.265	0.089	−2.96	0.003
Firm age	−0.015	0.010	−1.59	0.113
Year	0.021	0.007	2.95	0.003
Constant	−41.024	13.530	−3.03	0.002
Number of observations: 4458				

(if marginally).[5] The value of the two coefficients is fairly similar and we cannot reject the null hypothesis that they are the same. The coefficient of *Firm was spun-off from Bottom non-surviving parent* is close to zero and in fact is not statistically different from zero. Since the omitted case is de novo entry, the results suggest that a spin-off from a dying parent is not different, in terms of post-entry performance, than a de novo entrant. Finally, the above values also imply that the coefficient of *Firm was spun-off from Bottom surviving parent* is greater than the coefficient of *Firm was spun-off from Bottom non-surviving parent*, as predicted by theory.

Table 5 reports on the results of a third regression. This time we "split" the variable *Firm is Bottom and gave birth to spin-off* into two: *Firm is Bottom and gave birth to Good spin-off* and *Firm is Bottom and gave birth to Bad spin-off*. If a firm is not expected to exit, then all spin-offs originate in a type H worker. Such a worker-turned-entrepreneur expects a higher than average spin-off performance (as indicated in part (a) of Proposition 2). If however a firm is expected to exit, then *all* workers leave the firm and start their own firm. This set of entrepreneurs includes a mixture of H and L types. It follows that their average post entry performance is lower than the first set. Putting these considerations together, we have part (c) of Proposition 3. In terms of regression coefficients, we expect the coefficient on *Firm is Bottom and gave birth to Bad spin-off* to be greater than the coefficient on *Firm is Bottom and gave birth to Good spin-off*.

As mentioned earlier, we define a Good spin-off as one that survives for more than one year. We tried different thresholds and decided that one year was best. Ideally, the split should be such that a Good spin-off from a Bottom firm performs as well as a spin-off from a Top firm. The average life span of a spin-off from a Top firm is 6.49 years, whereas the average life span of a spin-off from a Bottom firm is 5.23 years (lower, as expected). Among the latter, if we exclude spin-offs who survived for survived for only one year, the average life span increases to 5.67 years. If we also exclude spin-offs who only survived for two years, then the average life span increases to 6.98 years.

5. Since the coefficients are not statistically different from each other (and are of similar magnitude), we ran a separate regression imposing the same coefficient on both variables. The coefficient's estimate is $-.270$ and statistical significance level increases considerably, with a p value of 0.047.

Table 5: Spin-off and parent performance.

Dependent variable: *Firm died in current period*				
Explanatory variables	Coef.	Std. Err.	z	$P > \|z\|$
Firm was created as a spin-off	−0.243	0.129	−1.88	0.060
Firm is Top and gave birth to spin-off	−0.104	1.035	−0.10	0.920
Firm is Bottom and gave birth to Good spin-off	0.410	0.396	1.03	0.301
Firm is Bottom and gave birth to Bad spin-off	1.896	0.633	3.00	0.003
Firm is Top	−2.100	0.228	−9.20	0.000
Founder's background is technology related	−0.317	0.097	−3.27	0.001
Founder's background is entrepreneurial related	−0.269	0.089	−3.00	0.003
Firm age	−0.015	0.010	−1.57	0.117
Year	0.021	0.007	2.96	0.003
Constant	−40.915	13.440	−3.04	0.002
Number of observations: 4458				

The results reported in Table 5 confirm the prediction that the coefficient on *Firm is Bottom and gave birth to Bad spin-off* is greater than the coefficient on *Firm is Bottom and gave birth to Good spin-off*. The coefficient on *Firm is Bottom and gave birth to Bad spin-off* is positive, large, and significantly different from zero. The coefficient on *Firm is Bottom and gave birth to Good spin-off*, by contrast, is not statistically different from zero. Nevertheless, the coefficient is positive, as predicted by the depletion effect of type I spin-offs. Finally, as predicted by part (a) of Proposition 3, the coefficient of *Firm is Top and gave birth to spin-off* is not statistically different from zero. Moreover, consistently with parts (a) and (b) of Proposition 3, the coefficient on *Firm is Bottom and gave birth to Good spin-off* is higher than the coefficient on *Firm is Top and gave birth to spin-off*.

■ **Robustness checks.** While our base results correspond to a limited number of regression equations, we find them to be fairly robust. We performed a series of robustness checks. First, in our base definition of exit, we exclude high-type firm exits by merger. The idea is that being acquired by another firm may reflect good performance rather than poor performance. We repeated the same regressions with the alternative definition that includes all exits. The results are very similar to our base results.

Second, in our base regressions we estimate the impact of spin-offs on parent performance by considering contemporaneous effects only. Alternatively, we may also consider one-year lagged effects. The results are again very similar.

Third, we re-estimated the results on a sub-sample consisting of years 1910–1942. Figure 3 suggests that this was a period where de novo end spin-off entry patterns were more stable. We obtain similar results to those on the 1895–1942, although, as expected, the levels of statistical significance are lower.

Fourth, we considered a variety of additional possible controls, including year effects and regional effects. The results are very similar. Finally, we also considered the possibility of firm fixed effects. Our random-effect logit panel regressions yield very similar results to our basic regressions.

6 Concluding remarks

Our model of "passive" learning about firm type and worker type, while relatively simple, leads to a rich set of implications regarding spin-off performance, parent performance, and the relation between spin-off and parent performance. In particular, our theory predicts a high correlation between spin-offs and parent exit, especially when the parent is a low-productivity firm. This correlation may corresponds to two types of causality. Whenever the spin-off is motivated by a worker learning that he would be a good entrepreneur (type I spin-off), the spin-off implies a depletion effect (good talent leaves the parent), which increases the probability of parental death. Whenever a worker learns that his employer is unlikely to survive for very long, the opportunity cost of starting a new firm becomes lower and all types of worker leave the firm to start a new one (type II spin-off).

Our empirical findings provide support for the various predictions derived from our theoretical model.

Our paper sheds new light on policy discussions regarding spin-offs. We are among the first ones to investigate and quantify the effect of spin-offs on the survival of their parents. Our results refine the existing literature in support of allowing and encouraging spin-offs. We show that, while spin-offs are likely to decrease the value and survival of their parent firms, the outcome of a spin-off is nevertheless socially beneficial, as it optimally reallocates human capital. This adds a more powerful criticism to the traditional argument against spin-offs, which narrowly views spin-offs as a business stealing process.

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