How far from the tree does the (good) apple fall? Spinout generation and the survival of high-tech firms

Abstract

We develop a model of spinout creation and survival to explain how the initial product market strategies of spinout may differ with respect to their parent and how this impact on their success. We test the model using detailed information on all the entrants in three markets in the Local Area Networking (LAN) industry during the 1990s. Our findings are consistent with the implications of the theoretical model. Concerning spin-out generation, the parent firm technological know-how plays an important role for diversification. In particular, we find that spinouts tend to imitate 'average' parents and 'keep away from the extremes' (i.e. parents that are too good or too bad with respect to the technological frontier). Concerning spin-out survival, we find that better spinouts survive longer and that there is no direct effect of a parent's know-how on spin-out's survival. Finally, too much diversification with respect to the parent firm can be detrimental for spin-out success.

1. INTRODUCTION

One of the most important determinants of economic growth and competitiveness is the speed at which firms react to innovative opportunities. In this respect, prior research has highlighted the role of new start-ups as important engines of growth and development at the industry level (Agarwal et al., 2007). Among the factors that explain this performance the 'pre-entry experience' of new entrants has been receiving much attention lately (Helfat and Lieberman, 2002). In several industries entrepreneurs with previous experience in the same or in related industries have successfully seized new opportunities and entered new markets by creating spinouts. Underlying this evidence lays the idea that spinouts are relatively more successful than other entrants because they take advantage of industry-specific knowledge which is embodied in their founder(s) and which has been inherited from the parent firm (Klepper, 2001; Klepper, 2009).

Theories of spinout formation can be grouped in three categories depending on the assumptions made about the reasons why employees leave the parent firm to set up an independent firm (Klepper, 2001). 'Agency theories' highlight the presence of disagreements and information asymmetries within the parent firms leading frustrated but 'brilliant' employees to leave the firm to independently pursue their own project in a new company (Klepper, 2007; Anton and Yao, 1995). 'Organizational capabilities theories' focus on the slow response of incumbents firms to radical innovative challenges (King and Tucci, 2002; Christensen and Rosenbloom, 1995; Henderson, 1993) paving the way to the creation spinouts and new start-ups. 'Employee learning theories' start from the assumption that employees can learn and exploit the knowledge of the firm they work for in order to: either replicate what the firm is doing or to diversify. Empirical investigations inspired by this theory have provided some interesting findings on the process of spinout formation in specific industries such as Lasers (Klepper and Sleeper, 2005) and Hard Disk Drives (Franco and Filson, 2006). However, some predictions remain to a certain extent unexplored.

For instance, the theory predicts that at birth spinouts produce a product that is 'similar but differentiated' from the one of their parents. How similar? No attempt has so far been made to analyze empirically the similarity in terms of market location of spinout with respect to the parent firm. In addition to this, the theory predicts that spinouts survival is increasing in their technological know-how. However, to what extent the probability to survive is also dependent on the market location with respect to the parent firm? These are the two main questions we tackle in this paper. In order to do this, we develop and test a model of spinout creation and survival which explicitly account for differentiation.

The implications of the model are tested by using detailed data on the evolution of the Local Area Networking (LAN) industry. We first identify every LAN manufacturer that have commercialized at least one product in one of the three major LAN markets (i.e. Hubs, Routers and Switches) between 1990 and 1999 the period of growth and consolidation of the industry. Then we trace the background of each firm by looking at their founders in order to identify parent firms and spinouts. Using detailed information on the price, and technical characteristics of the products commercialized in each of the three markets we are able to reconstruct the product entry strategy of spinouts with respect to their parent and see whether it has been beneficial for spinout success.

Our findings support the idea that the variety of the parent' activity in terms of products portfolio has a positive influence on spinout generation and that the technological know-how of the parent firm plays an important role for diversification. In particular, we find that spinouts choose to locate in the market close to 'average' parents and away from the extremes (i.e. parents whose technological know-how is either 'too good' or 'too bad'). Concerning spinout survival, we find that better spinouts survive longer and that there is no direct effect of parent's know-how on spinout's survival. Finally, too much diversification with respect to the parent firm can harm spinouts.

The structure of the paper is as follows. Section 2 reviews some of the existing theories of spinout formation. In Section 3 we present our theoretical model, highlight its major implications, and derive some testable hypotheses. Section 4 presents the empirical context of our analysis, the LAN industry, describes the data and the estimation method employed in the paper. Section 5 presents the main results. Implication and conclusions are contained in Section 6.

2. BACKGROUND LITERATURE ON SPINOUTS

In the last two decades, several studies have investigated, both empirically and theoretically, the process of (intra-industry) spinout formation and performance vis-à-vis other types of entrants.

From the empirical viewpoint, analyses of sectors as different as automobiles (Klepper, 2007), lasers (Klepper and Sleeper, 2005; Buenstorf, 2007), Hard Disk Drives (Agarwal et al., 2004; Franco and Filson, 2005), tires (Buenstorf and Klepper, 2010), semiconductors (Garnsey et al., 2008; Klepper, 2009), medical devices (Chatterji, 2009), TV-sets (Klepper and Simons, 2000) has produced a set of empirical regularities. In particular, better-performing firms tend to have higher spinout rates, and, in turn, the performance of spinouts is superior to the one of de-novo entrants. Other dimensions of spinouts creation have been investigated for specific sectors. For instance, for the case of lasers, Klepper and Sleeper (2005) show that the probability of a firm generating a spinout producing a particular laser depends on the parent's experience with that laser, rather than its general experience. In other words, spinout typically enter the market by offering a product which is similar to the one produced by the parents. Based on this evidence, several theories of spinout formation has been proposed, which can be grouped in three categories depending on the assumptions made about the reasons why employees leave the parent firm to set up an independent firm (Klepper, 2001).

A first set of theories focus on the agency relationship within the parent firm, by highlighting the role of information asymmetries (Anton and Yao, 1995) and disagreement within the parent firm (Klepper, 2007; Klepper and Thompson, 2010; Thompson and Chen, 2011). Since employers can appropriate the value of ideas revealed by their R&D employees, this can lead the latter to start their own business not to see their idea appropriated by the former. Disagreement theories instead focus on spinout formation resulting from different perception of employees' ideas value, which cause the rejection of their projects and lead them to leave the firm to independently pursue their own project in a new company.

A second set of theories, that analyze both spinouts and start-ups more in general, focus on the slow response of incumbents firms to radical innovative challenges based on organizational capabilities theories (King and Tucci, 2002; Henderson, 1993), value-chain network (Christensen and Rosenbloom, 1995) and fear of cannibalization of their existing business (Arrow, 1962), thus paving the way to the creation spinouts and new start-ups.

A third set of theories consists of two approaches based on employee learning theories. These approaches start from the same assumption that R&D employees can learn and exploit the knowledge of the firm they work for in order to either replicate what the firm is doing (Franco and Filson, 2006) or to diversify (Klepper and Sleeper, 2005). In the former case the premise is that the better a firms' knowledge the lower the wage an employee will accept to work for it as the greater is the prospect of appropriating the full value of the employer's R&D by starting a new firm. In the latter case the premise is that the more differentiated is the firm's market the higher is the probability that the R&D employee who leave the firm will develop a variant of the existing product. If pre-emption is too costly, the parent will gamble that they will not lose market shares to spinouts. These two approaches make several predictions. Some of them have been confirmed by prior analyses. For instance, the prediction that better parents (thus more knowledgeable) generate more spinoffs has found confirmation in the case of lasers (Klepper and Sleeper 2005). The prediction that spinouts survival is increasing in their technological know-how has been confirmed in the case of the Hard Disk Drive industry (Agarwal et al. 2004). Other predictions are contrasting and remain to a certain extent unexplored.

Franco and Filson (2006) predict that at birth spinouts produce a product that is similar to the parent's to exploit inherited knowledge. Klepper and Sleeper (2005) predict that the product is differentiated from the one of their parents in order to relax competition. However, no empirical analysis looks specifically at the market location of spinout with respect to the parent firm. In addition to this, both approaches predict that industry conditions favourable to the creation of niche markets are conducive to spinout formation and that the presence of multiple niches makes an industry suitable for entry by spinouts and for their survival as narrow product lines are likely to shelter spinouts from competition. However, no analysis has explicitly looked at the extent to what the probability to survive is also dependent on the market location with respect to the parent firm. This paper tackles these questions both theoretically and empirically. In so doing, it aims at enriching the existing literature on spinout formation and performance.

3. THEORY

In this section we develop a game-theoretic model of spinout formation which has two distinctive features. First, the effect of market competition on spinout entry is explicitly considered, as in Klepper and Sleeper (2005) and Franco and Filson (2006). This is done in the context of a Hotelling-like model, as in Klepper and Sleeper, with a focus on competition between the parent, which is initially the monopolist in the market, and the spinout. Second, the parental heritage is reflected in the entry (or development) cost for the spinout, which is lower the higher is the technological know-how of the firm (again, a similar assumption is made in Klepper and Sleeper), and the uncertainty on future performance which characterizes the spinout at entry, which is higher the higher is the (market) distance of the spinout from the parent.

3.1. Model

Spinout creation and survival is modeled as a three stage process. Initially, an incumbent P (the parent) acts as a monopolist in a market being located at the left extreme of a one-unit Hotelling line (the product space). We denote with $x_P = 0$ its position, and with c_P its unit cost of production.

In the first stage of the game, a potential entrant S (the spinout) exogenously receives the idea of a project for a new product, which is described by a location x_S on the Hotelling line and by a distribution of unit production cost, which we assume normal with mean value $\bar{c}_S$ and variance $\sigma_S^2(x)$, with $\sigma_S^2(x)$ increasing in x. The actual cost of S is drawn from this distribution, but it is known (exactly) only after production. In words, as in Jovanovic (1982) the potential spinout is characterized by a degree of uncertainty about its actual level of efficiency which is increasing in distance in market location between the parent and the spinout, because of relative lack of technological-know-how and market-know-how. We shall assume that $\bar{c}_S \leq c_P$: due to incumbency advantages, the spinout is (on average) less efficient than the parent.

Given the project, and knowing the position and efficiency of the parent, S decides whether to develop the project, thus entering the market, or not (obtaining a pay-off which is normalized to 0). In order to develop the product, the spinout must incur a fixed (and sunk) cost $F(c_P)$, which is an increasing and convex function of the *parent*'s unit cost of production. This assumption captures the idea that the spinout can build upon the parent's knowledge: the higher is the unit cost of the parent (i.e. the lower its technological know-how), the higher will be the entry cost for the spinout. Contrary to Campbell and Franco (2014), in the current version of the model, we do not explicitly consider the possibility that it is the parent to develop the project. While this is surely an important extension of the model to be developed, the current assumption can be justified by the inability of the parent to recognize the opportunity which forces the employee to reveal the idea.

In the second stage, if S decides to enter, firms compete by setting (simultaneously) the prices. *S* and *P*'s decision are based on the expected cost for *S* (i.e. on $\bar{c}_S$), since the spinout actual cost is revealed only after production. Moreover, we assume that *P*'s location and efficiency do not vary if S enters the market. The consumers' side is represented as in standard Hotelling game with unit demand. Consumers are uniformly located over the line. A consumer (located at *x*) who buys from *P* (*S*) obtains a utility level $u - tx^2 - p_P$ ($u - t(x_S - x)^2 - p_S$), denoting with $u > 0$ the reservation utility, with $t > 0$ the transport cost parameter, and with p_S and p_P the prices. The market is always covered, i.e. *u* is large enough that consumers always prefer to buy from one of the two firms. As usual in Hotelling models, *t* is inversely related to the intensity of price competition, and directly related to firms' market power.

In the third stage the spinout decides whether to stay or exit the market, on the basis of the actual unit cost value c_S. At this stage, we assume that continuing production does not entail further fixed cost. Staying in the market, *P* and *S* compete in prices keeping constant locations and costs. Exiting, *S*'s pay-off is normalized to 0.

For the sake of simplicity, we assume that *S* can look only one period forward. In other words, when deciding whether to enter the market (stage 1), *S* bases its decision on profits resulting from stage 2 only. Therefore, we start looking at the sub-game perfect equilibrium of the game resulting from stage 1 and stage 2.

In stage 2, demand functions for *S* and *P* are determined, as usual, by finding first the indifferent consumer, given *S* and *P*'s location and for given prices. Denoting with $\hat{x}$ such a consumer, her position is given by the solution of the following equation:

$$u - t\hat{x}^2 - p_P = u - t(x_S - \hat{x})^2 - p_S \tag{1}$$

which yields:

$$\hat{x} = \frac{p_S - p_P}{2tx_S} + \frac{x_S}{2} \tag{2}$$

From (2), demand and profit functions are determined as follows:

$$D_P = \frac{p_S - p_P}{2tx_S} + \frac{x_S}{2} \tag{3}$$

$$D_S = \frac{p_S - p_P}{2tx_S} + 1 - \frac{x_S}{2} \tag{4}$$

$$\Pi_P = (p_P - c_P)\left(\frac{p_S - p_P}{2tx_S} + \frac{x_S}{2}\right) \quad (5)$$

$$\Pi_S = (p_S - \bar{c}_S)\left(\frac{p_S - p_P}{2tx_S} + 1 - \frac{x_S}{2}\right) \quad (6)$$

Equilibrium prices are obtained by solving the system of first order conditions to yield:

$$p_S^* = \frac{2\bar{c}_S + c_P + t(4 - x_S)x_S}{3} \quad (7)$$

$$p_P^* = \frac{2c_P + \bar{c}_S + t(2 + x_S)x_S}{3} \quad (8).$$

Equilibrium profits are defined as:

$$\Pi_P^* = \frac{\left[\bar{c}_S - c_P + t(2 + x_S)x_S\right]^2}{18tx_S} \quad (9)$$

$$\Pi_S^* = \frac{\left[c_P - \bar{c}_S + t(4 - x_S)x_S\right]^2}{18tx_S} \quad (10)$$

therefore, in the first stage, S develops the product if:

$$\frac{\left[c_P - \bar{c}_S + t(4 - x_S)x_S\right]^2}{18tx_S} - F(c_I) \geq 0 \quad (11).$$

In the third stage, S remains in the market if the equilibrium price margin determined by price competition with S's unit cost equal to c_S is positive. Therefore, the condition for survival is:

$$c_S < c_P + t(4 - x_S)x_S \quad (12).$$

3.2. Model implications

The model yields two predictions. The first concerns: i) the distance in the market between the spinout and the parent. The second prediction concerns: ii) the spinout performance as measured by its survival (all proofs are in Appendix 1).

Increasing market distance from the parent has an unambiguous positive effect on spinout profitability, as it protects spinouts from direct competition with the parent. This effect is stronger the higher is the technological know-how of the parent, i.e. the lower is its unit cost of production, since the parent is a tougher competition in this case. This suggests that when the technological know-how of the parent is high, the product of the spinout must be sufficiently dissimilar from the parent for entry to be profitable. At the same time, a parent's low level of technological know-how entails higher development costs for the spinout. So, in this case entry will be profitable only when the distance in the market between the parent and the spinout is high. This leads to the following proposition:

PROPOSITION 1: *The relationship between the technological know-how of the parent and the distance in the market between the spinout and the parent is U-shaped.*

Results for spinout performance, as measured by its survival probability, are less clear-cut and depend on the other parameters of the model. Spinouts survival would depend on both their technological know-how, and on their parents' know-how. In particular, a spinout exits the market when its actual production cost turns out to be 'sufficiently' larger than expected when the entry decision was taken (see equation (12)).

Market distance between the parent and the spinout has two effects on survival probability. On the one hand, a larger distance implies a higher probability of sustaining a large actual cost for S due to an *uncertainty effect* (UE). Here the idea is that developing a product too dissimilar from the parent's entails an exploration of product design opportunities which are potentially rewarding but nevertheless unfamiliar and more risky for the spinout. On the other hand, a larger distance from the parent increases the set of cost values which allow S's to stay profitable, due to a *competition effect* (CE). If the intensity of price competition is not 'too high', i.e. if t is high enough and therefore product differentiation effectively limits the competitive pressure, UE prevails. This argument leads to the following proposition:

PROPOSITION 2: *If the intensity of price competition is sufficiently mild, spinouts' survival probability is decreasing in their market distance from their parent.*

3.3. Testable hypotheses

To empirically test our propositions we rely upon two datasets. The first one is a comprehensive dataset of firms that have been active in the LAN industry since its inception.[1] This dataset virtually includes all the companies that contributed to the birth and rapid expansion of the industry, those who tried and fail and those who began as start-ups and rapidly soared to market dominance (i.e. Cisco Systems). For each firm in the dataset we have collected information on their founders, entry date in a specific market, entry date in the industry, age and, for those that did not survived, date of exit and mode of exit (i.e. failure vs. acquisition). This information has been collected over the years from several sources such as: the D&B Million Dollar database, ABI-Inform, Annual Reports, Lexis-Nexis, CORPTECH. The second dataset includes 1,818 products marketed between 1990 and 1999, the period of take-off expansion and consolidation of the industry, in three LAN markets: hubs (536 products), routers (747 Products), and switches (535 products). For each product in our dataset we have information on: year of market introduction, technical characteristics, market price, and name of the manufacturer. This information has been collected from specialised trade journals such as *Network World,* and *Data Communications*, press releases and data sheets from manufacturers.

Information on company founders are employed to trace the genealogy of each firm and eventually link it to some specific parent(s) active in the industry. Using this information we have

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[1] LANs form the infrastructure for data communication. Over LANs data travel in packets from a possible sender to a data receiver according to rules defined by standards. The infrastructure of modern LANs is made up of different types of equipment (hubs, routers, and switches) which define different markets. The diffusion of office LANs for data communication started in the second half of the 1970s but the industry experienced a period of rapid growth from mid1980s and especially during the 1990s when new high-speed standards (Fast Ethernet, FDDI, ATM and Ggabit Ethernet) became available.

identified 97 spinouts.[2] Data on product characteristics and prices are employed to construct indicators that will be used in the empirical analysis. Each LAN product (i.e. hubs, routers, and switches) identifies a different market and consistently with Klepper and Sleeper (2005) our model considers the possibility that the spinout will initially enter into the same market of the parent firm.

To measure the distance in the market between the spinout and the parent firm we proceed in two steps. For each product in each market, hedonic price regressions are estimated and predicted prices are calculated. Predicted prices are then used to calculate two types of indicators. The first indicator measures horizontal distance in each market between the parent and the spinout at entry. The second indicator measures a firm's location with respect to the technological frontier at entry. Using the horizontal distance as proxy for market distance at entry between the parent and the spinout and the location with respect to the technological frontier as a proxy for the technological know-how of the firms, our Proposition 1 suggests that the market distance is high for high levels of parent technological know-how, decreases for lower levels of technological know-how and then increases again.

As no firm level data on market revenues or profits are available, we use firm survival as a proxy for the post entry performance of spinouts. In particular we trace the survival of these firms up to 2012. Of the 97 spinouts included in our sample only 13 survive up to year 2012. 84 spinouts instead exit the market either by failure (18) or acquisition (66). In our model spinouts survival depends on market distance in two ways. Due to the CE, product differentiation should compensate for a lack of technological knowhow of the spinout. Due to the UE, product differentiation increases the uncertainty concerning the profitability of the spinout. Based on Proposition 2 we thus expect a spinout survival probability to be decreasing (increasing) in the market distance from the parent if UE (CE) prevails

Predicted prices for the hedonic regression are also used to construct two additional indicators to include as controls in the empirical analysis: an indicator of parent product dispersion and an indicator of spinout technological know-how. Based on with Klepper and Sleeper (2005), we expect to find a positive relationship between parent product dispersion in a specific market and the probability to spawn a spinout. Similarly to Agarwal et al. (2004) and Franco and Filson (2006) we expect that spinout survival should increase in the technological know-how of the spinout.

4. METHODS

Entry by spinouts

As mentioned above, we have been able to trace the genealogy of 97 spinouts since the industry inception. However our detailed information on products is restricted to the interval 1990-1999. Therefore we will focus our analysis on the spinouts that originated during this time frame. Though this is a limitation, this is a crucial period in the evolution of the LAN industry because it coincides with its rapid growth and consolidation. In addition to this, 55/97 (or 57%) of the spinouts in our sample entered after 1989. Thus we expect our analysis to provide a detailed and comprehensive picture of the phenomenon.

We start by looking at the relationship between the spinouts and their parents. For all 55 spinouts we counted the number of times they entered the same market of the parent. This occurred in 39/55 (or 71%) of the cases. 9/39 (or 23%) spinouts initially entered the hub market, 17/39 (or 43%) entered the router market and 29/39 (or 74%) the switch market. Concerning the entry strategies of

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[2] Consistent with Klepper and Sleeper (2005), a firm is considered to be a spinout if one or more of its founders has previously worked for another LAN firm in the year prior to the spinout creation.

the spinouts, 24 (or 61%) of those that entered the same market of the parent also produced only one type of LAN equipment at entry. 14 (or 36%) of those that entered the same market of the parent also produced two types of LAN equipment at entry, and only one produced three types of LAN equipment.

These differences in the rate of entry reflect differences in the presence of parents across markets as well as differences in terms of economic opportunities. In the period under examination, hubs and routers were established markets while the switch market was at an initial stage of its life cycle. In this market, innovations in the equipment hardware combined with the definition of new standards for data communications (Fast Ethernet, ATM, FDDI, Gigabit Ethernet) led to the creation of submarkets thus providing further entry opportunities for spinouts. The pattern of entry into the four switch submarkets is depicted in Figure 1.

[FIGURE 1 ABOUT HERE]

For each submarket, each line in the panel reports the overall pattern of entry (left scale), a 4 periods moving average (thick line), and the cumulative number of spinouts amongst the new entrants (right scale). It can be seen that, despite some difference across submarkets, spinouts make the most out of the total number of new entrants. Consistent with the results of Klepper and Sleeper (2005) for laser, all in all these descriptive statistics indicate a substantial overlap between the product strategy of spinouts at entry and the product portfolio of their parents a preliminary analysis that paves the way for a more sophisticated test of our hypotheses.

Construct measurements

In order to test our hypotheses we need to construct several indicators of differentiation between spinout and the parent, and technological know-how for both parent and spinout firms, and product dispersion for the parent firm. To construct these indicators we follow closely the approach by Stavins (1995) and Fontana and Nesta (2006) based on hedonic price regressions.[3] We start from the assumption that it is possible to reduce the multi-characteristics structure of a LAN product *m* in market *k* to a single dimensional measure by projecting its characteristics *z* onto a linear scale as follows:

$$q_{mk} = \sum_j \beta_j z_{jmk} \tag{13}$$

where the weights β_j represent the marginal value of characteristic *j* that both consumers and producers place on the *jth* characteristic. These weights are approximated by regressing observed prices (deflated to 1996 US dollars using the sector specific deflator for telecommunication equipment provided by the US Department of Commerce, Bureau of Economic Analysis) on characteristics, as follows:

$$p_{mkit} = \alpha + \sum_j \beta_j z_{jmk} + \alpha_t + \varepsilon_{mkit} \tag{14}$$

Where p_{mkit} is the log of the observed price for model *m* introduced in market *k* by firm *i* at time *t*, α is a constant, and α_t is a time fixed effect. Table A1 in Appendix 2 summarizes the results from the

[3] Contrary to other high-tech products whose performance can be clearly evaluated along one or two dimensions (i.e. areal density in the case of HDD, microprocessor power in the case of PCs etc.), in the case of LAN equipment focusing on only one or even on a small subset of characteristic would bias the evaluation because of the presence of complementarities among the characteristics themselves. The hedonic price approach has the advantage of considering a wider number of technical characteristics, thus reducing the bias.

hedonic regressions run separately for each market *k*. The predicted price $\hat{p}_{mkit}$ reflects (by construction) the overall contribution *q* of each characteristic weighted by its estimated coefficient. We posit:

$$q_{mkit} = \hat{p}_{mkit} . \tag{15}$$

We use *q* to construct the following indicators.

Market distance. We compute an indicator of the distance between the parent firm and the spinout at entry year *t*. In this case we use *q* to compute the distance across products. For each market *k* we compute the mean Weitzman distance d^{c}_{kmst} of a given model *m* produced by the spinout *s* from all the models introduced by the parent *p* in the year prior to spinout generation *t-1*:

$$d^{c}_{kmst} = \frac{\sum_{n_{kp}}^{N_{kp,t-1}} \sqrt{\left(q_{kmst} - q_{n_{kp,t-1}}\right)^2}}{N_{kp,t-1}} \tag{16}$$

where $N_{kp,\,t-1}$ is the number of products introduced by the parent *p* in market *k* at *t-1*, q_{kmst} is the quality of model *m* by spinout *s* at entry into market *k* and $q_{n_{kp,t-1}}$ refers to model *n* by parent *p* in year *t-1*. Because of the squared differences, this measure does not distinguish between products with high and low level of *q*. Thus the product space is characterised as a horizontal scale in which the product locate. The further from the centre of the scale *c*, the more peculiar is the product with respect to the representative product of the parent firm. Given that a spinout may introduce several products at entry year *t*, we take for each spinout and each market the average distance d^{c}_{kst}.

Market distance will serve as dependent variable for analyzing the location in the specific market of spinout at entry and as explanatory variable for testing Proposition 2 of our model.

Technological know-how. As an indicator of technological know-how we use the location of a firm (both the parent and the spinout) with respect to the technological frontier. To construct the indicator we take *q* and use it to compute for every model *m* introduced in market *k* by firm *i* at time *t* its distance from the frontier as follows:

$$d^{f}_{kmit} = \max\left(q_{kit}\right) - q_{kmit} \tag{17}$$

where q_{kmit} refers to model *m* by firm *i* in market *k* at *t*. The higher d^{f}_{kmit} the farther the model is from the technological frontier. Given that a firm may introduce several products and may be active in more than one market in a given year, we compute for each firm and market the lowest distance from the frontier:

$$d^{f}_{kit} = \min\left[d^{f}_{kmit}\right]_{kit} \tag{18}$$

The lower the measure, the higher is a firm's technological know-how in a specific market. The technological know-how of the parent firm in the year prior to spinout creation will serve as explanatory variable for testing the implications of our model. The technological know-how of the spinout at entry will be employed as control variable in the analysis of spinout performance.

Parent product dispersion. This is an indicator of the width of a parent's product line. To construct it we proceed in two steps. First, for each market *k*, we construct a measure of product dispersion within the parent's product portfolio:

$$\sigma_{kpt} = \frac{\sum_{m=1}^{M_{pt}} \left(q_{kmpt} - \overline{q}_{kpt} \right)^2}{M_{kpt}} \quad where \quad \overline{q}_{kpt} = \frac{\sum_{m=1}^{M_{pt}} q_{kmpt}}{M_{kpt}} \tag{19}$$

where *M* is the number of products introduced by the parent *p* in market *k* for a given year. The overall product dispersion in market *k* is defined as:

$$\sigma_{kt} = \frac{\sum_{n=1}^{N_{kt}} \left(q_{knt} - \overline{q}_{kt} \right)^2}{N_{kt}} \quad where \quad \overline{q}_{kt} = \frac{\sum_{n=1}^{N_{kt}} q_{knt}}{N_{kt}} \tag{20}$$

where *N* is the number of products introduced by all the firms for the same year. The relative dispersion index for parent *p* in market *k* is defined as:

$$R_{kpt} = \frac{\sigma_{kpt}}{\sigma_{kt}} \qquad (21).$$

The (lagged) relative dispersion index will serve as an explanatory variable in the analysis of spinout creation.

Estimations

We carry out two types of estimations. We start by employing a Maximum Likelihood Heckman model to estimate the probability of spinout generation and location with respect to the parent firm. In the first stage the dependent variable is the probability for incumbent *i* to spawn a spinout in market *k* in period *t* (P_{ikt}). The main explanatory variable in this estimation is the measure of the parent product dispersion in market *k* in the previous period *(t-1)*. As in Klepper and Sleeper (2005) we add other explanatory variables capturing the characteristics of the parent firm. These variables include the (logarithm of) the total number of years the parent was active in market k and its squared value, the (logarithm of) the total number of years the parent was active in producing LAN equipment, a 1-0 dummy equal to 1 for parent firms that were acquired and 0 for those that were not, and the (logarithm of) the parent age. A full vector of entry-year dummy variables for the parent firm is also included in this first stage. In the second stage, we estimate the market distance of the spinout from the parent firm at entry. In this case the dependent variable is the mean Weitzman distance between the parent and the spinout as constructed above. The explanatory variables are indicators of the technological know-how of the parent firm as captured by the parent distance from the technological frontier in market *k* in the previous period *(t-1)* and its squared value. A full vector of entry-year dummy variables for the spinout is also included.

To estimate the hazard of exit for spinouts we employ a complementary log-logistic discrete time duration model (Bayus an Agarwal, 2007). In this case the main explanatory variable is the distance of the spinout from the parent firm at entry. Additional explanatory variables include the (logarithm of) spinouts' age, the technological know-how of the parent firm when the spinout was spawned, and the technological know-how of the spinout at birth. A full vector of entry-year dummy variables for the spinout is also included.

5. RESULTS

Results from the two steps ML Heckman estimation are reported in Table 1.

[TABLE 1 ABOUT HERE]

Similarly to Klepper and Sleeper (2005) in each year beginning with its year of entry and extending through 1999, each firm in our sample is considered as a potential parent of a spinout initially entering one of the three markets in the LAN industry (i.e. hubs, routers or switches). Thus there are many observations per firm and 8,919 in total. Column 1 reports the results of the first step in which the dependent variable is equal to one when the parent spawns a spinout in the same market it is active. The coefficient estimate of parent product dispersion is positive and highly significant (at the 0.01 level). The estimate implies that the higher its product dispersion within a specific market k the more likely is a firm to spawn a spinout in that specific market.

The coefficient estimates of the linear and quadratic terms for prior years of production of equipment k are positive and negative, respectively. They are both very significant at the 0.001 level. These results indicate that the probability of a parent spawning a spinout in the same market it is active at first increases in a parent's past experience in that market, reaches a peak, and then declines.

The coefficient estimate of the number years of production of LAN equipment is negative and very significant at the 0.001 level. This result suggests that a firm's success in the industry does not increase the probability of spawning a spinout in the same market k it is active in. On the contrary, overall success of the parent firm reduces the probability of spinout creation for the firms in our sample.

The coefficient estimate of parent age is positive and very significant at the 0.001 level. This result suggests that older firms have higher probability of spawning a spinout in the same market k they are active. To the extent that firm age is also positively correlated to the size of the firm, this result suggests that bigger firms are more likely to spawn spinouts then smaller ones. Finally the coefficient estimate of the acquisition dummy is not statistically significant. This result indicates that the rate of spinout creation is not influenced by the mode of exit of parent firms.

Column 2 in Table 1 reports the results of the second stage of the Heckman estimation. In this case the dependent variable is the horizontal distance in the market k between the parent firm and the spinout at time t as captured by the mean Weitzman distance. As we observed this distance only for those parents that have spawned a spinout, the number of observations is a subsample of the initial set of firms. The coefficient estimate of parent age is now insignificant. The coefficient estimates of the linear and quadratic terms for the distance from the technological frontier (our proxy for parent technological know-how) in market k in the year prior to spinouts creation are negative and positive, respectively. They are both significant at the 0.05 level. These results suggest that the relationship between the technological know-how of the parent and the market distance between the parent and the spinout is non linear. Figure 2 below depicts the relationship for the interval of values in our sample.

[FIGURE 2 ABOUT HERE]

As it can be seen, for high levels of parent technological know-how the market distance is high. It decreases for lower levels of technological know-how and then increases again. This result is consistent with Proposition 1 in our model.

We now turn to the analysis of the performance of spinouts. The coefficient estimates and standard errors of the complementary log-logistic estimation are reported in Table 2 where the dependent variable is the hazard of exit and the explanatory variables are measured at spinout birth and added in sequence.[4]

[TABLE 2 ABOUT HERE]

Column 1 reports the results of our baseline estimation when only the effect of time on the hazard of exit is considered. The coefficient estimate is negative and significant. This suggests that the hazard of exit is relatively higher at young age. In column 2 we add the parent distance from the technological frontier our control for the parent technological know-how. The coefficient estimate of this variable is positive but not significant.

In column 3 we add the control for the technological know-how of the spinout. The coefficient estimate of the spinout distance from the technological frontier this variable is positive and significant at 0.05 level. This result indicates that better spinouts tend to perform better in terms of survival. Interestingly, after the inclusion of this variable, age becomes only weakly significant.

In column 4 we add the market distance variable. The coefficient estimate of this variable is positive and significant at the 0.05 level. This result indicates that the higher the market distance between the spinout and the parent firm at entry the higher the hazard rate for the spinout. The magnitude of this effect is quite high as a one standard deviation increase of market distance around the mean leads to a 83% increase in the hazard rate for the spinout. This result is consistent with Proposition 2 in our model which predicts that the survival probability of the spinout should be decreasing in the market distance from the parent.

In addition to this, it is interesting to note that after the inclusion of the indicator of market distance in the regression, the variable capturing the technological know how of the spinout becomes only weakly significant. Also, age ceases to be significant. This suggest that failing to control for the market location of the spinout with respect to its parent may lead to an overestimation of the effects of age and the technological know-how on the hazard of exit.

6. DISCUSSION AND CONCLUSION

We proposed a model to explain the location of the spinouts in the market with respect to their parents and to analyze how this location influences the post entry performance of spinouts. On the basis of this model we then empirically analysed the drivers of spinouts creation and survival in the LAN industry.

The model builds upon Klepper and Sleeper (2005) but extends its scope in several ways. First, it does not focus only on *whether* spinouts enter or not in the same market of the parent but it specifically tackles the issue *where* they locate in the market with respect to the parent conditional upon entry in the same market. Second, and most importantly, the model establishes a relationship between the market distance and the technological know-how of the parent firm which was not explicitly built into prior models of spinout formation. Third, the model establishes a relationship between market distance and the performance of the spinout, another aspect that was not explicitly modelled by Klepper and Sleeper (2005).

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[4] In this analysis we only focus on exit by failure and treat acquisitions as censored observations. Prior analysis on a subsample of these observations (Fontana and Nesta, 2009) has found that the higher the technological know-how the higher the survival or the higher the probability of exiting by acquisition for those than do not survive. In addition to this they have found that spinouts have a lower hazard rate than other start-ups.

The model makes two predictions. First, there is a positive but non linear (U-shaped) relationship between the technological know-how of the parent and the distance in the market between the spinout and the parent. Second, for sufficiently low levels of price competition between the spinouts and the parent, spinouts' survival probability is decreasing in their market distance from their parent.

We used the model as a guide in our empirical analysis in the LAN industry. Our empirical analysis provided two sets of results. Concerning spinouts creation, our findings showed that the variety of a parent activity, as captured by its product dispersion in a specific market, has a positive influence on spinout generation. In addition to this, our findings generally confirmed the predictions of the model.

Both these sets of results have important implications for the analysis of the determinants of spinout creation and survival. Our finding that entry by spinout in a specific market is positively related to the extent of product dispersion of the parent in that market is consistent with the results of Klepper and Sleeper (2005) for lasers, Brittain and Freeman (1986) and Garvin (1994) for semiconductors and further qualifies them. Not only each market the parent is active in is a potential source of spinout creation but the more disperse *within the market* are the products, the higher is the probability that a spinout is spawned.

Perhaps the most important implication of our findings concerns the role played by the technological know-how of the parent for both diversification and survival. As stressed by the prior literature (Klepper and Sleeper, 2005; Klepper, 2001), spinouts inherit capabilities from their parents which give them a competitive advantage with respect to other start-ups (Klepper and Simons, 2000). These capabilities tend to be *distinctive* and clearly influence the post entry behaviour of the spinout (Garvin, 1983; Holbrook et al., 2000). On the one hand, spinouts clearly benefit from having 'good' parents because this translates into lower development costs for their innovative idea. Low development costs enable them to explore in principle a wider range of market locations for their products. On the other hand, they will try to shelter themselves from direct competition with the parent by locating in the market as farther away as possible always within the boundaries of their inherited skills. Our finding about the positive but non linear effect of parent technological know-how on spinout location provides a clear evidence of these effects.

In terms of survival our findings that spinout survival is decreasing in the market distance between the parent firm and the spinout indicates that 'too much' diversification with respect to the parent may be detrimental for the new venture. In our model, this evidence is explained by the prevalence of the uncertainty effect over the competition effect. One reason why the uncertainty effect may prevail over the competition effect is once again provided by the prior literature which has highlighted that the inherited capabilities are *limited* to the prior knowledge of the parent firm. This means that the better the technological know-how of the parent the harder will be for the spinout to outperform the parent which is a requirement to survive in the market after entry.

Alongside these major implications some of our results also confirm and extend previous findings on spinouts in high-tech industries. Our finding concerning the positive but non linear relationship between parent experience in a market and the probability to spawn a spinout resonates with Klepper and Sleeper (2005). Contrary to them, we also find a negative relationship between the parent prior experience in the industry and the probably of spinout generation. Taken together both results indicate that the probability of spawning is influenced only by the prior experience in producing a specific type of LAN equipment not by the general experience in the industry. An additional implication is that the most successful firms in the LAN industry may tend to retain their best employees (Campbell et al. 2012).

Finally, our findings have also implications for the existing theories of spinout formation. In our review we posed two questions that were relatively underexplored by the theories. The first question was related to the initial strategy of market positioning with respect to the parent. The second question was related to the profitability of the chosen strategy. In this respect employee learning theories of spinout formations make two rather contrasting predictions: either spinouts learn to replicate what their parent do or they learn to diversify. Our results reconcile the two predictions by showing that the strategy chosen by spinout is the outcome of the tension between the capabilities that spinouts inherit from their parents and the capabilities required to successfully outcompete them in the market. While a good parent is certainly a good source of capabilities for the spinouts the successful implementation of the new ideas by the spinout will necessarily be constrained by their inherited capabilities to a close contour of the parent product portfolio. Venturing beyond this boundary is likely to increase the risk of the project and reduce its profitability.

In conclusion, the idea that spinouts are relatively more successful than other entrants because they take advantage of industry-specific knowledge inherited from the parent firm still provides useful insights to understand patterns of entry and industry evolution. From the viewpoint of the business strategy though, the pre-entry experience that represents an advantage for spinouts with respect to other new entrants may become a ‘constraint‘ when they need to compete with their parent. Within this context, the most successful spinouts turn out to be those that neither exactly replicate the same product strategy of the parent nor differentiate too much from it or, in other words, the ‘best‘ apples turn out to be are those that do not fall too far from the tree.

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List of Tables

Table 1: Determinants of spinout generation in market k at time t. Two step Heckman estimation

VARIABLES	(1) Spinout generation	(2) Market distance parent-spinout
Parent product dispersion in market k at t-1	0.824	
	[0.290]**	
Prior years parent active in market k (Log)	2.604	
	[0.438]***	
Prior years parent active in market k squared (Log)	-1.602	
	[0.227]***	
Number of years parent active in producing LAN equipment (Log)	-0.590	
	[0.125]***	
Parent acquired (Dummy)	0.050	
	[0.209]	
Parent age (Log)	1.902	0.268
	[0.191]***	[0.191]
Parent distance from frontier in market k at t-1		-2.578
		[1.267]*
Parent distance from frontier in market k at t-1 squared		2.468
		[1.006]*
Spin Year (Dummy)	No	Yes
Born Year (Dummy)	Yes	No
Constant	-9.061	2.312
	[0.797]***	[0.981]*
Athrho		-0.385
		[0.508]
Lnsigma		-0.120
		[0.175]
Total Observations	8,919	
Censored Observations	8,826	
Uncensored Observations	93	
Wald Chi-square	239.95**	
Log Pseudo-Likelihood	-459.4321	

Robust standard errors in brackets
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 2: Determinants of spinout survival. Complementary log-logistic estimation.

VARIABLES	(1)	(2)	(3)	(4)
Spinout age (Log)	-0.643	-1.065	-0.691	-0.439
	[0.213]**	[0.273]***	[0.357]+	[0.505]
Parent distance from frontier at spinout birth		0.405	0.523	0.691
		[0.352]	[0.450]	[0.682]
Spinout distance from frontier at birth			0.675	0.833
			[0.336]*	[0.456]+
Market distance parent-spinout				0.605
				[0.277]*
Constant	-3.429	-3.195	-5.406	-7.810
	[0.421]***	[0.765]***	[1.787]**	[2.900]**
Observations (Number of firms x Year)	1,965	606	549	542
Zero outcomes	1947	596	540	535
Positive outcomes	18	10	9	7
Chi-square	9.093**	15.290**	21.520**	31.960**
Log Likelihood	-98.680	-44.878	-37.637	-28.76

Robust standard errors in brackets

*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

List of Figures

Figure 1: Entry by spinout and LAN submarkets

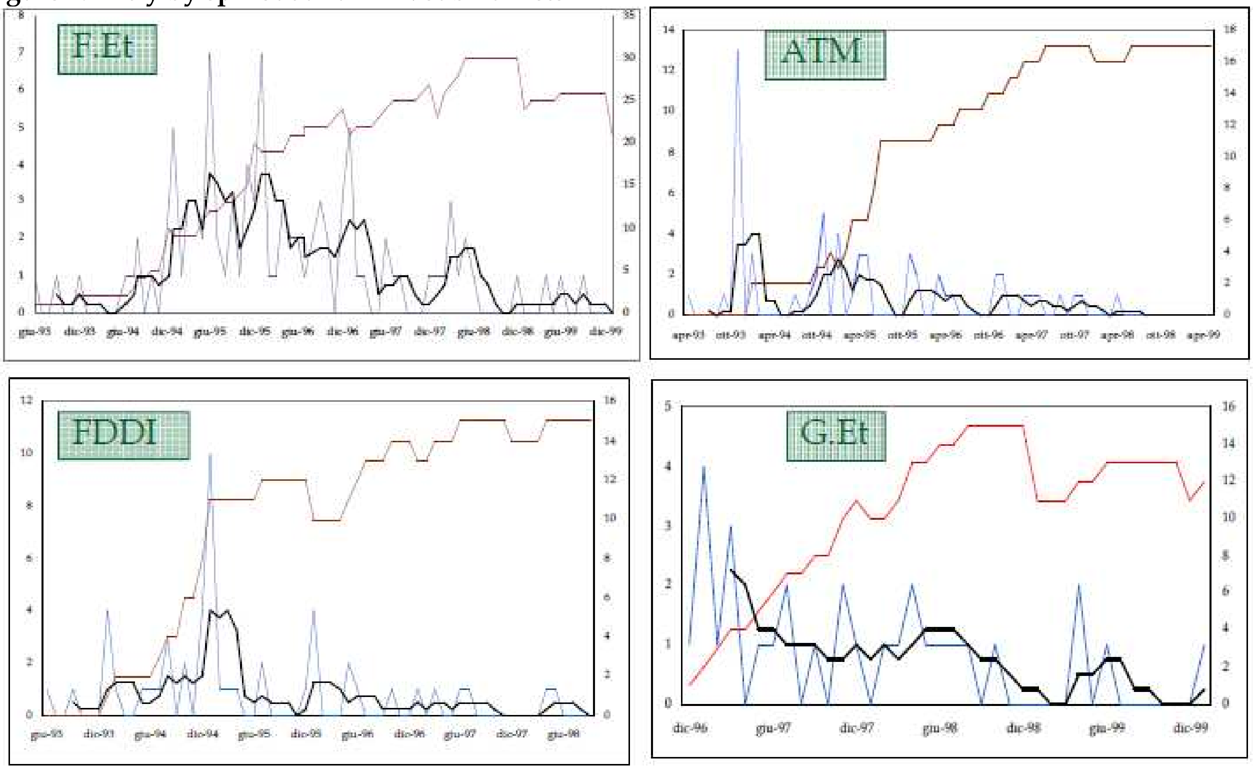
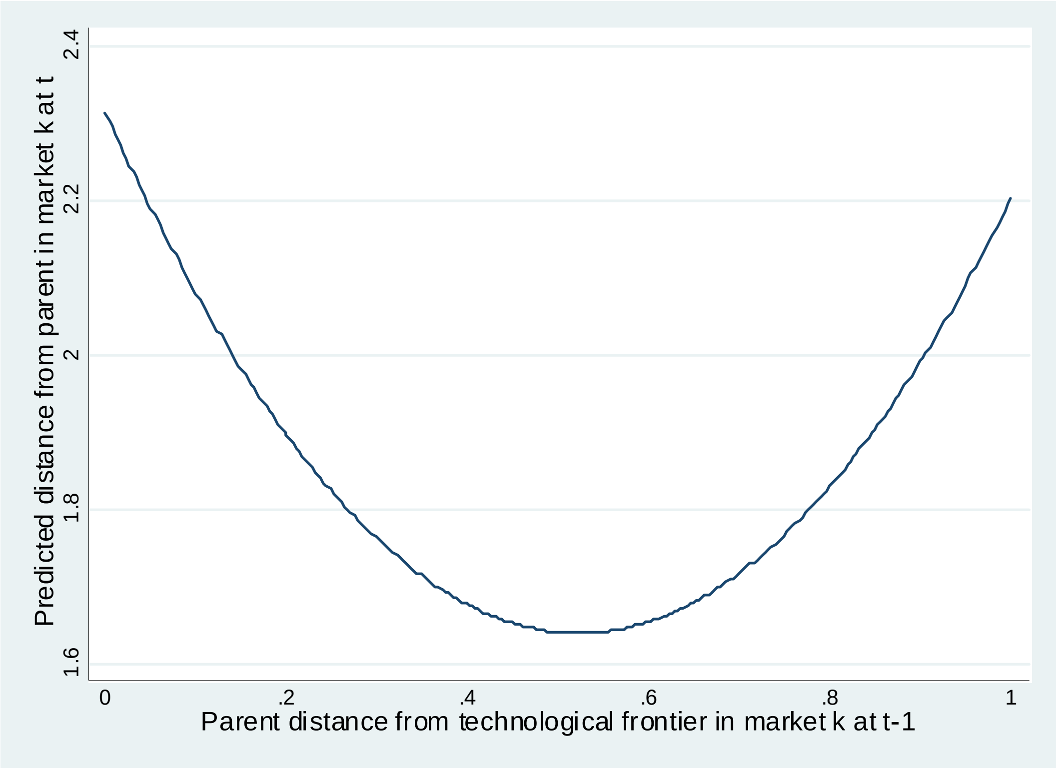


Figure 2: The non linear relationship between the technological know-how of the parent and spinout-parent market distance



Appendix 1

Proof of Proposition 1

The locus of c_P *and* x_S *for which* $\Pi_S^*(x_S, c_P) - F(c_P) = 0$ *is given by:*

$$\frac{\left[c_P - \bar{c}_S + t(4 - x_S)x_S\right]^2}{18tx_S} - F(c_P) = 0$$

By applying the implicit function theorem we obtain:

$$\frac{dx_S}{dc_P} = \frac{-\dfrac{2\left[c_P - \bar{c}_S + t(4 - x_S)x_S\right]}{18tx_S} + F'(c_P)}{\dfrac{\left[c_P - \bar{c}_S + t(4 - x_S)x_S\right]\left[2tx_s(4 - 2x_S) - \left(c_P - \bar{c}_S + t(4 - x_S)x_S\right)\right]}{18tx_S^2}}$$

The denominator is positive (in particular, $2tx_s(4 - 2x_S) - \left(c_P - \bar{c}_S + t(4 - x_S)x_S\right)$ *is positive if* $c_P - \bar{c}_S \leq 0$*, as we assumed. The sign of the numerator is ambigous: however, since* $F'(c_P)$ *is increasing,* $\frac{dx_S}{dc_P}$ *must only turn from negative to positive, so that in general the relationship between* x_S *and* c_P *is U-shaped.*

Proof of Proposition 2

Given equation (12), the survival probability for S is given by:

$$\Pr(c_S \leq c_P + t(4 - x_S)x_S) = \frac{1}{2}\left(1 + erf\,\frac{c_P + t(4 - x_S)x_S - \bar{c}_S}{\sigma(x_S)\sqrt{2}}\right)$$

where erf stands for the error function. By deriving with respect to x_S*, and denoting* $z = \frac{c_P + t(4 - x_S)x_S - \bar{c}_S}{\sigma(x_S)\sqrt{2}}$ *one obtains:*

$$\frac{1}{2}\frac{2}{\sqrt{\pi}}e^{-z^2}\frac{t(4-2x_S)\sigma(x_S)-\left[c_P+t(4-x_S)x_S-\overline{c}_S\right]\sigma'(x_S))}{\sigma^2(x_S)\sqrt{2}}$$

which is negative when:

$$\frac{\sigma'(x_S)}{\sigma(x_S)}\geq\frac{t(4-2x_S)}{\left[c_p-\overline{c}_S+t(4-x_S)x_S\right]}$$

The right quantity turns out to be decreasing in t (since $c_P-\overline{c}_S\leq 0$*), therefore for t sufficiently large the inequality is satisfied, and survival in decreasing in distance.*

Appendix 2

Table A1: OLS regressions on observed hub prices

BACKPLANE CAPACITY (LOG)	0.229
	[0.055]**
MAXIMUM NO OF PORTS (LOG)	0.551
	[0.066]**
TOKEN RING (DUMMY)	0.336
	[0.141]*
OTHER STANDARDS (DUMMY)	0.669
	[0.179]**
MANAGEMENT SOFTWARE (DUMMY)	0.185
	[0.118]
CONSTANT	6.052
	[0.307]**
Observations	518
Rsq	0.802

Dependent variable: logarithm of deflated list product price. Robust standard errors in brackets.
** p<0.01, * p<0.05, + p<0.1

Table A2: OLS regressions on observed router prices

MAXIMUM NO OF LANS (LOG)	0.503
	[0.069]**
MAXIMUM NO OF WANS (LOG)	0.376
	[0.058]**
FRAME RELAY SUPPORT (DUMMY)	0.166
	[0.081]*
ISDN & ATM SUPPORT (DUMMY)	0.045
	[0.132]
SONET SUPPORT (DUMMY)	0.425
	[0.213]*
OSPF ALGORITHM SUPPORT (DUMMY)	0.071
	[0.107]
RIP1-2 ALGORITHM SUPPORT (DUMMY)	-0.222
	[0.150]
APPLETALK PROTOCOL SUPPORT (DUMMY)	-0.053
	[0.104]
DECNET PROTOCOL SUPPORT (DUMMY)	0.186
	[0.129]
IPX PROTOCOL SUPPORT (DUMMY)	-0.059
	[0.111]
SNA PROTOCOL SUPPORT (DUMMY)	0.141
	[0.073]*
TCP/IP PROTOCOL SUPPORT (DUMMY)	0.244
	[0.167]
XNS PROTOCOL SUPPORT (DUMMY)	0.141
	[0.108]
CONSTANT	7.785
	[0.402]**
Observations	731
Rsq	0.850

Dependent variable: logarithm of deflated list product price. Robust standard errors in brackets.
** $p<0.01$, * $p<0.05$, + $p<0.1$

Table A3: OLS regressions on observed switch prices

BACKPLANE CAPACITY (LOG)	0.191
	[0.038]**
NO OF ETHERNET PORTS (LOG)	0.068
	[0.030]*
NO OF FAST ETHERNET PORTS (LOG)	0.014
	[0.040]
NO OF FDDI PORTS (LOG)	0.031
	[0.069]
NO OF TOKEN RING PORTS (LOG)	0.116
	[0.043]**
NO OF 100VG ANY-LAN PORTS (LOG)	0.185
	[0.131]
NO OF ATM PORTS (LOG)	0.043
	[0.061]
NO OF GIGABIT ETHERNET PORTS (LOG)	0.370
	[0.066]**
VLAN CAPABILITY (DUMMY)	0.145
	[0.115]
CHASSIS (DUMMY)	0.815
	[0.160]**
FIXED CONFIGURATION (DUMMY)	-0.064
	[0.090]
CONSTANT	8.341
	[0.334]**
Observations	513
Rsq	0.666

Dependent variable: logarithm of deflated list product price. Robust standard errors in brackets.
** p<0.01, * p<0.05, + p<0.1