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Spin-offs are not the Only Story: Demand Start-ups in High-tech Industries

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Abstract

We investigate how the knowledge of de novo entrants in an industry affects the choice of entry and the survival rates of these firms. We make a novel distinction between spin-offs (new ventures with founders from the incumbent industry), demand start-ups (new ventures with founders from downstream markets/applications) and inexperienced start-ups (new ventures with founders from finance, research or consulting). Analyses of 1997-2007 data on start-ups from the semiconductor industry support our hypothesis that both spin-offs and demand start-ups have entry advantages compared to inexperienced start-ups. Furthermore, spin-offs have a higher likelihood of entry in standard product categories, and of survival in both standard and customized product categories, while demand start-ups have a higher likelihood of entry in both standard and customized products and of survival in customized products only. Such

differences are due not only to the type of knowledge (technology versus market) that entrants possess, but also to the dimensions of that knowledge (cumulativeness, contextuality, tacitness and accessibility).

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Abstract

We investigate how the knowledge of *de novo* entrants in an industry affects the choice of entry and the survival rates of these firms. We make a novel distinction between spin-offs (new ventures with founders from the incumbent industry), demand start-ups (new ventures with founders from downstream markets/applications) and inexperienced start-ups (new ventures with founders from finance, research or consulting). Analyses of 1997-2007 data on start-ups from the semiconductor industry support our hypothesis that both spin-offs and demand start-ups have entry advantages compared to inexperienced start-ups. Furthermore, spin-offs have a higher likelihood of entry in standard product categories, and of survival in both standard and customized product categories, while demand start-ups have a higher likelihood of entry in both standard and customized products and of survival in customized products only. Such differences are due not only to the type of knowledge (technology versus market) that entrants possess, but also to the dimensions of that knowledge (cumulativeness, contextuality, tacitness and accessibility).

1. Introduction

In recent years interest in the phenomenon of entrepreneurship in high technology industries has grown. Much of this interest has been sparked by the success rate of new enterprises in the Silicon Valley in such industries as semiconductors, lasers, and biotechnology (Braun and MacDonald, 1978; Geroski, 1995; Holbrook, *et al.*, 2000; Klepper, 2001). The literature identifies different types of new enterprises according to their relationship with existing firms in industry (Helfat and Lieberman, 2002). Diversifying entrants are established firms entering new or established markets through acquisitions, joint ventures or internal growth. Spin-offs (or spawns) are independent companies founded by employees of incumbent firms in the same industry, while *de novo* entrants are stand-alone companies with no prior employment or financial relationship to established firms in the industry. Within these distinctions, researchers have attempted to analyze how the resources and capabilities of these companies differ, and how such differences may affect the timing and strategy of entry and the performance and success rate of these companies over time (Klepper and Thompson, 2005; King and Tucci, 2002; Gompers, *et al.*, 2003).

Much of the most recent research in the field of new entrants has focused on the category of spin-offs or spawns (Klepper, 2002a, 2002b; Klepper and Sleeper, 2005; Chatterji, 2009; Agarwal, *et al.*, 2004). Spin-offs have provided a rich source for research both because they are widespread in industries such as semiconductors, disk drives, and lasers, and because of arguments made about their ability to capitalize on knowledge gained during the course of their founders' employment in incumbent firms. By contrast, much less work has been done to look past the assumed advantages of entering from the same industry or to understand the resources and capabilities of *de novo* entrants that lack such explicit ties to incumbents or the resources of diversifying firms. This comes as a surprise given the extensive literature on the role of firms on the demand side and, in particular, user firms in innovation. Broad studies on sectoral systems have identified the active role of demand in sectors such as software, machine tools and semiconductors (Mowery and Nelson, 1999; Fontana and Malerba, 2010). In addition, since the pioneering work of von Hippel (1988; 2005) on lead users, numerous case studies and survey analyses have highlighted the major role of users in innovation processes across a variety of sectors. Even more to the point, a burgeoning literature on user entrepreneurs has shown that users from outside of incumbent industries are able to enter and compete with existing companies by applying their knowledge of their own needs to produce and even commercialize innovative solutions (Hienerth, *et al.*, 2006; Shah and Tripsas, 2007).

This paper will therefore attempt to dissect this category of *de novo* entrants by distinguishing between new enterprises coming from the demand side and new enterprises with no previous experience in either the incumbent or its client industries. We call this first category 'Demand Start-ups'. These are firms that use a technology or component part in either their products or their production processes. In this study, therefore, demand is synonymous with users or user firms. Users may also produce and sell this same technology or component on the open market, making them vertically integrated user firms. This definition is admittedly broader than other classifications that limit users to those that benefit directly from a technology or from components (such as semiconductors) but exclude firms that sell products or services incorporating that technology or those components (von Hippel, 2005). Our reasoning for this is that users are key players in innovation because they have unique knowledge bases that are different from those of firms in the industry. We call the second category of *de novo* entrants 'Inexperienced Start-ups'. The founders of these companies may come from university or research backgrounds, or from finance and venture

capital firms. What makes them different from demand-based entrants is the lack of any pre-experience in an industry setting in which the technology or components are used. Therefore they lack direct knowledge and experience both from the incumbent industry and from the market and its applications.

A second focus of the literature on new entrants in high technology industries is the type of knowledge that these companies possess. It is often asserted that spin-offs may benefit from technological know-how and/or market knowledge passed from the parent to the spawn through the founders of the new venture. Before leaving their parent firms, in fact, employees may get access to key information regarding new innovations or technical developments, or to markets and social networks that allow them to identify market opportunities not yet exploited by the parent firm. Yet in order to fully understand whether or not spin-offs benefit from such knowledge transfers more than *de novo* entrants, it is necessary to examine in greater detail the specific characteristics of these types of knowledge.

Knowledge has four dimensions that are useful for our analysis. First, knowledge may be more or less cumulative. Cumulativeness refers to the degree by which the generation of new knowledge builds upon current knowledge. One can identify three different sources of cumulativeness. The first source is cognitive. Existing learning processes and past knowledge constrain current research, but may also generate new questions and new knowledge. The second source is related to the organizational capabilities of the firm. Organizational capabilities are firm-specific and generate knowledge which is highly path-dependent. They implicitly define what a firm learns and what it can hope to achieve in the future. A third source is market feedback, such as the "success-breeds-success" process. Innovative success yields profits that can be reinvested in R&D, thereby increasing the probability to innovate again (Nelson and Winter, 1982).

A second dimension of knowledge is the degree of contextuality. Some knowledge is quite related to the specific context in which it is developed. The context can be the sectoral context or the local context. The contextual dimension of knowledge makes that knowledge 'sticky' (von Hippel, 1994).

A related dimension of knowledge is the degree of tacitness or codification. Tacit knowledge is socially embedded in routines (Nelson and Winter, 1982), it is often team based, and resident in individual human capital. In general the more knowledge is codifiable the more easily it can be transferred across firms. Most type of knowledge has different combination of tacitness and codification (Winter, 1987). The more knowledge is tacit the more difficult it is to transfer. In general, the resource-based view of the firm stresses how tacitness can limit the market ability of key resources and also make them difficult to imitate (Barney, 1986; Barney and Arikan, 2002; Makadok, 2001; Montgomery, 1995; Prahalad and Hamel, 1990).

A final dimension of knowledge is its degree of accessibility (Malerba and Orsenigo, 2000). Accessibility refers to opportunities for acquiring external knowledge by an actor within a defined sectoral context. If external knowledge is easily accessible, transformable into new artefacts and exposed to a lot of actors (such as customers or suppliers), then innovative entry may take place (Winter, 1984). If, on the other hand, advanced integration capabilities are necessary to access new knowledge (Cohen and Levinthal, 1989), entry is more difficult and the sector is more likely to be dominated by large, established firms.

This paper will use these dimensions of knowledge to explore the types of advantages spin-offs, demand start-ups, and inexperienced start-ups may have to enter and survive in a new industry context.

2. Theoretical Framework And Hypotheses

2.1. Founder Origins and Entrepreneurial Strategies

The early literature in management provides little support for the idea that the origins of the founders of a company determine its strategy to enter an industry. Rather, the thrust of this literature is to argue that entry is determined by such factors as profit objectives (Geroski, 1995), competitive strategy and market opportunity (Porter, 1988) and entrepreneurial spirit (Knight, 1989; Shrader and Simon, 1997). For most authors, the origins of the managers involved, and the types of knowledge thereby accumulated by these individuals, do not play a significant role in the choice of entry.

By contrast, the recent work on new entrants and, in particular, spin-offs, argues that such companies inherit knowledge from their parent firms and that this knowledge shapes their strategy and performance (Klepper and Sleeper, 2005). Two types of knowledge are generally identified in such studies: technological knowledge about new innovations and developments in the specific field, and market knowledge (Agarwal, *et al.*, 2004). Market knowledge may involve information concerning opportunities or needs in the market that are not yet fulfilled by current competitors, a more general understanding of the application areas in which technologies are used, or knowledge about regulatory and marketing processes.

These two types of knowledge have very different characteristics. Technological knowledge tends to be cumulative in nature, such that current research builds on past research and knowledge. Technological knowledge may have tacit elements that derive from the experience built up by individuals or groups around a research area. But it may also be codified, making it easier to transfer between individuals, departments or even firms through markets for technology. Knowledge that is codified may be made accessible ex-ante to users through the use of licenses, software tools, or other mechanisms. In such cases, the barriers to entry into an industry will be much lower. Market or application knowledge, by contrast, is much less cumulative and more contextualized. New opportunities are not necessarily dependent on cognitive learning processes or organizational capabilities already in place. Moreover, information about the market tends to be much more tacit, local and 'sticky' and often rests in the minds of the individuals who have the relevant experience in that specific market (von Hippel, 1994). In medical devices, for example, knowing how to navigate the process of obtaining coverage from Medicare to reimburse the use of a device is critical for success (Chatterji, 2009). As a result, market knowledge is less accessible ex-ante and is more likely to be developed once firms have been involved in the market through interaction with customers, other firms or through experience. For these same reasons, the barriers to entry represented by market or application knowledge may be high.

Given such observations, it may also be argued that such differences may vary in importance across different types of products. In more standardized products, for example, technological knowledge will be more relevant, while market and application knowledge may be only slightly relevant. In customized products, by contrast, market and application knowledge will be highly relevant, while firms may not need extremely in-depth technological knowledge to produce an adequate solution to a need. In this context, the

technology that they need may be accessible through licenses or other types of agreements with outside suppliers.

How does this apply to different types of entrants? Spin-offs are companies founded by employees from parent companies in the incumbent industry. As a result, they will most likely have in-depth experience and technological knowledge within the industry. They may or may not have extensive market and application knowledge drawn from their experience and social networks. If they do not have the necessary market and application knowledge, and this knowledge is highly tacit and contextualized in nature, the more difficult it will be for spin-offs to fill this resource gap. Demand start-ups, on the other hand, will most likely have extensive market and application knowledge of both suppliers and customers that might prove valuable for the new venture. They will also most likely have a deep understanding of their application areas and the specific needs of users in their fields as well. For example, this was the case for a small number of start-ups in the typesetting industry who applied their experience as users to create innovative solutions for emerging customer preferences (Tripsas, 2001). They will also have links to industry associations and networks in their specific markets. While they may not have extensive technological knowledge, they may be able to access that knowledge that has been codified and made available ex-ante to external users. We thus propose:

Hypothesis 1a: Spin-offs will be more likely to enter high-tech industries in standardized product categories where technological knowledge is key for competitiveness.

Hypothesis 1b: Demand start-ups will be more likely to enter in customized product categories where market knowledge is key for competitiveness or standardized product categories where barrier to entry are low.

If the characteristics of knowledge have different effects on entry, what impact might they have on the survival of these new entrants within the industry? Again, the general management literature does not identify knowledge at the origin as a key to survival. Specific research into the dynamics of spin-offs, however, provides evidence that the same pre-entry resources and capabilities that increase the likelihood of entry in to an industry seem to enhance survival as well. Companies whose founders and employees come from the incumbent industry have insider status which makes their initial resource endowments superior to other entrants. They are likely to bring in knowledge, routines, and processes and links with the industry's network that overcome the limits of newness. Their social capital will also be more closely linked to the industry in which they are operating and thus more valuable than that of other new entrants that lack prior incumbent affiliation (Agarwal, et al., 2004). This position is supported by much of the literature on entrants. Dunne et al. (1988) found that de novo entry in US manufacturing industries was more common but less successful than entry by diversifying firms. In his analysis of the automobile industry, Klepper (2002) showed that early entrepreneurial spin-offs survived longer than other entrants. In the US laser industry, Sleeper (1998) found that spin-offs survived longer than start-ups with less relevant experience, and survived as long as experienced (diversifying) entrants. Finally, Thompson (2002) found a positive relationship between pre-entry experience and long term survival that went beyond scale economies and learning subsequent to entry. Although the mechanisms by which such results occur is still a question of debate among scholars, there is substantial evidence that the pre-entry resources and capabilities of entrants affect not only initial success, but the long-run survival rates of these companies.

We believe that many of these same advantages benefit demand start-ups. Demand start-ups bring strong marketing knowledge and contacts from the downstream industry. They will have knowledge of the routines and processes used in applications for the technology and links with other customers. They may also bring in complementary knowledge about production processes in the downstream sector, distribution networks, sales experience and relationships with regulatory or other government institutions important for survival in a specific market.

By contrast, inexperienced start-ups will have few of these benefits. They will lack of any pre-experience in an industry setting in which the technology or components are used. They therefore bring in no specific knowledge of routines or processes regarding production or commercialization. They also lack links with customers or industry affiliations that may be critical for success. We therefore propose:

Hypothesis 2: Both spin-offs and demand-start-ups will have a higher likelihood of survival than inexperienced start-ups.

The benefits of pre-entry experience mentioned above, however, may vary across different product categories. Standardized product involve knowledge that is more cumulative and may require greater absorptive capabilities. Survival in standardized products may also depend more heavily on ability to coordinate R&D and production and require more in-depth knowledge of both (Hollbrook, et al., 2000). The challenges to survival in standardized products are therefore higher. Although demand start-ups may access technological knowledge initially through licenses to enter an industry, they are less likely to have the advanced capabilities to build long term advantage in the technology and therefore in standardized product categories. Customized products, by contrast, require contextual knowledge of specific markets and applications. This is sticky and developed through experience and interaction with individuals that possess such knowledge. Yet this type of knowledge is also less cumulative and less difficult to absorb. Therefore, while the barriers to entry might be high, once entered, this knowledge can be developed through interaction and experience. Thus, for the firms that have entered in this product category, the challenges to survival are lower in customized products. We therefore propose:

Hypothesis 3a: Spin-offs will have a higher likelihood of survival in both standardized and customized product categories.

Hypothesis 3b: Demand start-ups will have a higher likelihood of survival in customized product categories.

3. The Semiconductor Industry

From a sectoral systems perspective, developments in semiconductors have involved a wide range of actors and networks. As a science-based industry, universities and research laboratories have been heavily involved in R&D in semiconductors. Similarly, firms in the industry, with the strong backing of financial institutions and venture capital, have invested heavily in scientific research aimed at both product and process technologies. Government institutions have supported developments in semiconductors for both military and strategic purposes. But demand has also played an important role in the development of the semiconductor industry. In the early years of the semiconductor industry, demand from the military, aerospace, and computers was fundamental in determining both the speed and

direction of technological change in semiconductors, especially in the United States (Langlois and Steinmueller, 1999). In the 1970s, new markets in telecommunications, automobiles and consumer electronics emerged and had a significant impact on the development of advanced capabilities by European and Japanese semiconductor producers (Malerba, 1985).

In the period under examination here, two related factors increased the relevance of application knowledge for product development in semiconductor technology. The first was the widespread use of semiconductors in wireless communications and mass consumer products such as video games and televisions. These new markets had very different characteristics from the more traditional markets (computers and telecommunications) for semiconductors. Consumer markets were highly fragmented into a vast array of product niches, each with different requirements. Product life cycles were also much shorter due to the rapidly changing demands of consumers (Brown and Linden, 2009). Under such conditions, the stable architectural standard that had dominated in previous decades (the Wintel standard) was no longer applicable. Unlike the personal computer, consumer products more often required specialized semiconductors that would allow producers to differentiate their products from those of their competitors in order to gain market share. Rather than build a system around a standardized chip, moreover, users began to demand chips that were designed for their specific systems and specifications. This required more design-in efforts by suppliers and a closer interaction between users and designers. In-depth knowledge about the features required by user firms and by system integrators became a key criterion for success in these new markets.

A second set of developments came from the technology side. The increased adoption of Complementary Metal Oxide Semiconductor (CMOS) production processes weakened the interdependence of product design and manufacturing. Because designers could work with relatively stable design rules, they were less bound by decisions concerning process technologies. The creation of standardized interfaces between components and Electronic Design Automation (EDA) tools also allowed a modular system to develop in which blocks of intellectual property ('design blocks') could be exchanged and licensed across products and companies (Ernst, 2005). Finally, developments in CAD (Computer-Aided Design) software and in communications networks made it possible for companies to exchange huge amounts of data and design specifications (Macher and Mowery, 2004). As a result of these developments, the interdependence between product design and manufacturing was weakened in many product segments in semiconductors and specialist firms were able to enter the industry at both the design and the manufacturing stages. The so-called 'fabless' firms, and the silicon foundries they partnered with for production, began to compete with existing integrated device manufacturers (IDMs) by offering users customized designs and shorter production cycles. At the same time, user firms gained access to both the tools and knowledge bases necessary to be able to design customized chips around simple components to satisfy the rapidly changing and fragmented demands of their markets. Semiconductor chips were no longer forced to fit an industry standard, but could be made to comply with user requirements and user systems. The knowledge boundaries between users and suppliers were weakened and the barriers to access supplier knowledge were lowered.

These developments provide a basis for understanding why semiconductors offer a rich and highly dynamic environment in which to study the importance of demand start-ups. The pace of technological change was rapid and there were a large number of entrants into the industry during this period. Semiconductor devices became an increasingly strategic component in many user product categories. At the same time, users required more and more customization in chip design for their own systems and product lines. Yet the

application specific knowledge required for designing customized semiconductor devices was often tacit and too complex for users to transfer it easily to their suppliers (Glimstedt, *et al.*, 2010). As von Hippel (1994) and Ogawa (1998) have argued, users are more likely to perform innovative activities if information about user needs is 'sticky' compared to technical information about solutions. It has also been argued that users are more likely than suppliers to innovate if their expectations of innovation related benefits are higher (Riggs and von Hippel, 1994). This was certainly the case in many areas of semiconductor devices where customized components provided strong competitive advantages to users with respect to rivals in their end markets. Furthermore, agency costs were raised by the fact that users wanted customized solutions while suppliers were seeking to develop general solutions that could be sold to a wide range of users in order to keep their development costs down and reach the economies of scale needed in such capital intensive production (Macher *et al.*, 2007). Finally, users had gained access to the capabilities and technologies needed to design their own chips (Ernst, 2005; Brown and Linden, 2009). User firms, therefore, had both the proper incentives and capabilities to innovate in semiconductors during the two decades under study.

4. DATA AND METHODS

4.1. Data Sources

The data used in this paper come from several sources. The main source is *Semiconductor Times*, a magazine published monthly by a private consultancy company specialized in the semiconductor industry called Pinestream Communications. Pinestream Communication records new start-ups in the industry each month and provides a profile of each company in the magazine. Each issue of *Semiconductor Times* reports announcements about new start-ups, a description of their activities as well as information on their founders and the founders' backgrounds. These data are then collected in an online database with restricted access. Further sources of information on new semiconductor firms included the *EE-Times* magazine and *IC Insight*, a market research firm. Given their limited coverage of new semiconductor start-ups, these latter sources have mainly been used to cross-check information provided by Pinestream Communication. Additional information on founders' backgrounds was collected from sources such as the Hoover database, and from online resources such as Zoom Info and ABI INFORM. Through ABI INFORM we searched the specialized trade press for information on the activities and job mobility of founders. This information was then cross checked and eventually integrated with information collected through specialized web sites such as Silicon Valley Links (Links SV). Finally, for a subset of founders we were able to retrieve their complete CVs as published in Linked-In. Whenever possible, further information was also extracted from company web sites.

4.2. Building the Dataset

We used the information provided by Pinestream Communications to construct a sample of new semiconductor start-ups founded between 1997 and 2007. The dataset includes 1,010 firms. For each firm, we gathered the following information: company name, geographical location, year founded, (eventual) year of exit, submarket of entry, name, education, and background of the founders (up to three founders were retrieved).

4.3. Constructing Measures

Pre-entry experience. We used the background of the founders to classify the firms in our sample into three groups. Firms founded by entrepreneurs who were previously employed in a semiconductor firm (SIC 367) were classified as SPIN-OFFS. Firms that were founded by entrepreneurs with a background in the semiconductor software and/or in semiconductor

design and production (i.e. Electronic Design Automation) were also classified as spin-offs. In total, 412 spin-offs were identified. The second group of firms are those founded by entrepreneurs who were previously employed in industries that rely heavily upon semiconductors as inputs for their final product (i.e. computers and office equipment, consumer electronics, communication equipment, automobiles). While these founders had some industry related pre-entry experience they should be distinguished from spin-offs since they worked in industries that are mainly user industries of semiconductors. We define firms in this category as DEMAND START-UPS. In total, 346 firms belong to this group. It should be noted that many producers of computers and office equipment (SIC 357), consumer electronics (SIC 36 except 366 and 367), and communication equipment (SIC 366) are 'vertically integrated' (i.e. they possess a semiconductor related division and/or a semiconductor R&D laboratory). Firms with at least two founders who worked for these specific divisions were treated as spin-offs. Otherwise they were considered as demand start-ups. The last group of includes 252 firms such as university start-ups and firms founded by people previously active in finance, venture capital or business consultancy. We define this group of firms as INEXPERIENCED START-UPS.

Classifying start-ups with only one founder (458 firms) did not represent a problem. Start-ups founded by a team of entrepreneurs (552 firms) were generally classified into one of the above categories if at least two of the founders were employed by a semiconductor, a demand, or an inexperienced parent respectively. Problematic were the cases of start-ups whose founders were all from different backgrounds (260 firms). In these cases we followed Klepper (2007) and classified firms in one of the above categories on the basis of the background of the most influential founder (i.e. a founder with previous entrepreneurial experience and/or previous innovative experience).

Entry by product category. For our analysis of entry, we identified from the company profiles reported in *Semiconductor Times* the main submarket of activity for the firms in our database. Given their young age and lack of resources firms tend to enter just one submarket at birth. We identified the following submarkets. Memories (including DRAM; Flash; SRAM and other memories), Processors (including microprocessors, microcontrollers, and DSP), Application-specific integrated circuits (ASIC's), Devices for Electronic Design Automation-EDAs, Analog Devices (including amplifiers, regulators, data conversions, and interfaces) and Other devices (including measurement and testing devices, power semiconductors, MEMS, and optoelectronics).¹ These submarkets were further aggregated into three macro-categories: STANDARDIZED SEMICONDUCTORS that include Memories and Processors; CUSTOMIZED SEMICONDUCTORS that include ASICs and EDAs; OTHER SEMICONDUCTORS that include analog devices and other devices. Table 1 reports the number of firms by semiconductor category and year of entry.

[Insert Table 1 about here]

On average around 84 new start-ups entered the industry each year with the bulk of new entries (71.2%) concentrated before 2003. The peak of new entrants occurred in 2000. The distribution of entry by product categories reflects the evolution of demand for semiconductor devices away from standardized products and towards customized devices. Customized products account for most of the entries (54.3%) driven by the demand for

¹ To identify the submarkets we followed the classification provided by IC Insights (2007) and employed also by (Corsino and Gabriele, 2011).

application-specific semiconductors for telecommunications, computers and consumer products. Standardized products, by contrast, registered the lowest share of total entries (18.1%) mostly in microprocessors, which was a mature market. A sizeable portion of entries occurred in the 'Other Semiconductors' category (27.6%) mainly due to entry in the analog device sub-segment.

It is noteworthy that of the total of 1010 new entrants over this period, 34% were Demand start-ups. We know of no study to date that has made this distinction between type of *de novo* entrant, explicitly identifying new entrants with backgrounds from the demand side. The size of this group indicates that it represents an important category for future investigations and that it will be important in future research not to treat these entrants as a residual category, but to identify user firms within the category of *de novo* entrants.

Almost half of entrants in standardized semiconductors are spin-offs (48.9%) followed by demand-start-ups (34.1%) and inexperienced start-ups. Almost 37% (36.8%) of entrants into customized products are demand start-ups. A sizeable number of spin-offs also enter this category (38.4% of total entrants). However, the share of spin-off entering customized product categories (51.2%) is lower than the corresponding share of demand start-ups (58.4%).

Firm performance. Consistent with the recent literature on pre-entry experience, we measure performance in terms of survival of the new ventures. Approximately 34.0% of inexperienced start-ups exited the industry by the end of the period. They account for the majority of exits in our sample (36.1%). Just over one-fifth (21.0%) of spin-offs exited the industry while only 19% of demand start-ups exited. Table 2 reports the relationship between firm background and survival for the firms in our sample.

[Insert Table 2 about here]

In general, experienced start-ups performed better than inexperienced firms: 79.8% of them were still alive at the end of the period compared to 66.3% of inexperienced start-ups. Among experienced firms, demand start-ups performed better than spin-offs in terms of survival. The Chi-square test statistics rejects the null hypothesis of independence between firm background and survival.

Control variables. To our measure of pre-entry experience we add a series of controls related to both firm and founder characteristics. First we control for the size of the firm. FIRMS SIZE is constructed as the total number of employees at the time of entry. In addition to this we control for the status of the semiconductor firm. FABLESS FIRM is equal to one if the firm is a fabless and zero otherwise. Finally, we control for the characteristics of the founder(s). SERIAL ENTREPRENEUR is equal to one if the founder, or at least a member of the founders' team, had previously founded another firm. DUM 1997-2002 is a time dummy equal to one if entry has occurred before the burst of the dot-com bubble.

5. Results

We present two sets of results. First, we analyze how pre-entry experience effects entry into semiconductor product categories. We carry out this analysis by estimating a Multinomial Probit model in which the dependent variable is the probability to enter into one of the product categories defined above (i.e. STANDARDIZED SEMICONDUCTORS; CUSTOMIZED SEMICONDUCTORS; OTHER SEMICONDUCTORS). Pre-entry experience is captured by the spin-off and demand start-up dummies. Several other variables are added as controls as specified

above. Second, we analyze the impact of pre-entry experience on firm survival by performing a discrete time duration analysis using a complementary log-logistic function to model the hazard of exit (Bayus and Agarwal, 2007). Finally, we control whether the impact of pre-entry experience on the hazard of exit is moderated by the specific product category the firms enters. Table 3 summarizes the descriptive statistics for all the variables included in our analysis.

[Insert Table 3 about here]

5.1. Results for Entry

In Table 4 we report the results of our entry analysis carried out using a Multinomial Probit estimation. Column (1) and (2) report the regression coefficients for entry into standardized and customized semiconductor respectively. The reference category is 'Other Semiconductors'. Column (3) reports the coefficients for entry into customized products as contrasted with entry into standardized products.

[Insert Table 4 about here]

Our results provide evidence that knowledge embodied in founders influence the probability to enter into a specific semiconductor category. In column (1), the coefficient of spin-off is positive and significant, suggesting that spin-offs are more likely to enter into standardized semiconductors than into other semiconductor categories. This result supports Hypothesis 1a. The coefficient for demand start-ups in column (2) is also positive and significant suggesting that these firms are more likely to enter into customized semiconductors. The positive coefficient for demand start-ups in column (1) indicates that these firms also are more likely to enter into standardized semiconductors. Both results support Hypothesis 1b. As expected, the coefficient for spin-offs in column (2) is not significant. Our control variables behave as expected with firm size impacting positively on the probability to enter and with fabless firms more likely to enter standardized products rather than customized.

Table 5 reports the predicted probability of each entry mode.²

[Insert Table 5 about here]

It can be noted that for the median firms with average characteristics in our sample, the overall probability to enter into standardized semiconductor production is 18%, the probability to enter into customized is 55%, and the probability to enter into other semiconductors is 27%. These differentials in the probabilities clearly reflect the differences in the opportunities available to firms in the time period under consideration here. We then computed the marginal effects of the significant variables. For our pre-entry experience dummies, we computed the discrete change from being an inexperienced to being a spin-off or demand start-up respectively. All changes are reported as absolute and relative change in probability. Our results confirm that pre-entry experience impacts differently on the mode of entry depending on the type of knowledge embodied in the founders. Although technological knowledge matters, its impact on the probability to enter is positive only in the case of standardized semiconductors. In this case, being a spin-off increases the probability

² The predicted probabilities were computed using the median values of the continuous variables (size) and the mean values of the dichotomous variables (spin-off, demand start-up, fabless firm, serial entrepreneur, time dummy). The marginal effects were computed as discrete change, holding all other independent variables constant at their mean or median values.

to enter into standardized semiconductor by 67%. Application knowledge, as embodied in demand start-ups instead, eases entry into customized semiconductors. In this case, being a demand start-up increases the probability to enter into customized semiconductor by about 4%. Being a demand start-up also allows to enter standardized semiconductors though the marginal effect is in this case lower than in the case of spin-offs (46% vs. 67% respectively). We take both results as an indication of the role played by the presence (or lack thereof) of knowledge barriers to entry into these markets. When knowledge entry barriers are low, as in the case of standardized semiconductors, both spin-offs and demand start-ups can enter. When knowledge entry barriers are high, as in the case of customized semiconductors, demand start-ups that possess market or application specific knowledge are favored.

5.2. Results for Survival

Table 6 reports the results of our survival estimation. Model (1) contains the pre-entry experience dummies, the time baseline and the cohort dummy. Controls are then added sequentially.

[Insert Table 6 about here]

In our final specification (Model (4)), both the coefficients for spin-off and demand start-ups are negative and significant suggesting that these two groups have relative lower hazard rates with respect to the base category (i.e. inexperienced firms). This evidence supports Hypothesis 2 according to which both type of firms have a higher likelihood of survival with respect to inexperienced firms. Interestingly, start-ups enjoy a lower hazard rate than spin-offs suggesting that previous experience gained in application sectors is relatively more beneficial for survival than experience gained in the same industry. However, the null hypothesis of equality of coefficients for the two variables could not be rejected suggesting that demand start-ups perform just about the same as spin-offs in terms of survival.

Finally, we study whether the impact of pre-entry experience on survival is moderated by the type of semiconductor market the firm has entered. This analysis is presented in Table 7.

[Insert Table 7 about here]

Model (4) reports again our benchmark regression. In model (5) we analyze the effect of entry into standardized semiconductors. The coefficient of spin-off is negative and significant indicating that they enjoy a relatively lower hazard of exit with respect to inexperienced firms. In model (6) we analyze the effect of entry into customized semiconductors. In this case, the coefficients for spin-offs is again negative and significant suggesting that demand start-ups enjoy a lower hazard of exit than inexperienced firms. These results support Hypothesis 3a according to which spin-offs will have a higher likelihood of survival in both standardized and customized product categories. Concerning demand start-ups, in model (5) the coefficient for demand start-ups is not significant indicating that these firms that entered into standardized semiconductors did not perform differently than inexperienced firms in the same market in terms of survival.

In model (6) the coefficient for demand start-ups is negative and significant suggesting that this type of firm enjoy a lower hazard of exit with respect to inexperienced firms. This result supports Hypothesis 3b according to which demand start-ups will have a higher likelihood of survival in customized product categories. Also, it can be noted that in this case, demand start-ups experience a lower hazard rate than spin-offs suggesting that in customized semiconductors previous experience gained in application sectors is relatively more beneficial for survival than technological knowledge.

6. Discussion

Our results can be summarized in the following way. Pre-entry experience either in technology or in a market/application area provides an entry advantage over lack of experience in either. Therefore both spin-offs and demand start-ups have entry advantages compared to inexperienced start-ups.

However, the knowledge that new firms have at their start (technological vs market/application) and the accessibility of knowledge that is required to enter standard or custom products affects the likelihood of entry in standard or custom products: spin-offs are more likely to enter into standard products while demand start ups may enter both standardized or custom products. This is so because the technological knowledge required for standard products can either be inherited from a parent semiconductor company that has accumulated technological knowledge over time (as in the case of spin-offs) or obtained in a codified form through markets for technology (as in the case of demand start-ups). So, for these two reasons knowledge barriers to entry in standardized products are rather low. On the other hand, barriers to entry into custom products require a highly contextual knowledge related to specific markets and/or applications. This contextualized knowledge is highly tacit and not easily accessible ex-ante without direct involvement in that context. Therefore demand start-ups may inherit this tacit knowledge, while spin-offs have difficulty to obtain it before entry. So knowledge barriers to entry in custom products are higher for spin-offs than for demand start ups.

The situation is different for survival. It is confirmed that spin-offs and demand-start ups have advantages over inexperienced entrants for reasons similar to the ones explained above concerning knowledge about technology and markets/applications. However, the factors affecting the survival of spin-offs and demand start-ups in standard and in customized products differ from the factors that affect their entry in these types of products. This is because the challenges to survival are different from the barriers to entry. For entry, the technological knowledge needed for standard products can be accessible more easily (through markets for technologies) than application knowledge for customized products because of its greater codified element (compared to the more contextual dimension of application knowledge). However, once a new firm has entered standardized products, cumulative technological knowledge becomes relevant for survival. Therefore spin-offs, which already possess advanced tacit and codified technological knowledge enjoy higher survival rates than demand start-ups in standard product categories. On the contrary once spin-offs have entered custom products activity, they can absorb and develop contextual knowledge through its daily activities and interaction with customers.

7. Conclusions

This paper makes several points. First and foremost, it highlights that analyses of new entrants in an industry should move beyond the distinction between spin-offs and *de novo* entrants, where spin-offs refer to firms coming from the same industry and *de novo* entrants refer to new firms coming from a variety of origins. Our analysis stresses the importance of introducing a category of entrants, demand start-ups, given the important role which demand and market needs play in industrial dynamics. The direct implication of this paper is the need to integrate the literature on entry and industrial dynamics with recent contributions on user innovation and the role of demand in sectoral systems.

Second, our analysis directly relates the types of entrants and their survival rates to the different types of knowledge that these firms possess. It expands the current literature by

moving such analyses beyond the simple distinction between technological knowledge (related to spinoffs) and application knowledge (related to demand start-ups) by adding a discussion of the dimensions of such knowledge. This paper argues that technological knowledge is highly cumulative in nature, that it may have both tacit and codified elements, and that the codified elements may be transferred through markets for technologies. By contrast, application knowledge is highly contextual, cannot be easily be transferred in a codified way, but can be developed by firms once they start operating in a specific context. In a sense, technological knowledge and application knowledge have different degrees of accessibility and cumulativeness which affect both entry and survival.

Third, our analysis relates knowledge, entry and survival to a basic distinction between product types: standard versus customized. Standard products in a high-tech industry have a very high technological content, while custom products have a very high application content. Therefore in these two markets one may find barriers to entry (low for technological knowledge and high for application knowledge) that differ from challenges to survival (high for technological knowledge and low for application knowledge). This creates a matching between the knowledge that spin-offs and demand start ups have and the knowledge required for their entry and survival in these products groups

Of course, this paper represents just a first step into a much more detailed and finer grained analysis of the role of demand start ups in high technology industries. One major advantage of this research is that we consider a very large sample of entrants firms (more than one thousand), so that results can be considered rather general. However, the analysis has some limitations. We may identify two main ones. New entrants have been classified in terms of the origin of the main founders, at the exclusion of the background of other founders and employees. Second, our measure of performance relates to survival, while other dimensions such as profitability, market share and growth, are not considered. Overcoming these limitations will be the objective of future research.

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TABLE 1: ENTRY BY PRODUCT CATEGORY

	Standardized	Customized	Other	Total
1997	21	65	17	103
1998	19	56	25	100
1999	28	70	30	128
2000	38	80	40	158
2001	20	67	37	124
2002	20	48	39	107
2003	12	59	33	104
2004	11	52	29	92
2005	11	35	10	56
2006	2	14	16	32
2007	0	3	3	6
TOTAL	182	549	279	1010

TABLE 2: FIRM BACKGROUND AND SURVIVAL

	Survived	Exited	Total
Spin-off	326	86	412
Demand Start-up	279	67	346
Inexperienced start-up	167	85	252
TOTAL	772	238	1010

Chi-square statistics = 19.5036***

TABLE 3: DESCRIPTIVE STATISTICS

VARIABLE	N	MEAN	S.D.	MIN	MAX
Product category	1010	2.09	0.67	1	3
Dead	1010	0.23	0.42	0	1
Spin-off	1010	0.41	0.49	0	1
Demand Start-up	1010	0.34	0.47	0	1
Standardized	1010	0.18	0.38	0	1
Customized	1010	0.54	0.49	0	1
Size	1010	32.5	14.18	1	95
Fabless firm	1010	0.42	0.49	0	1
Serial entrepreneur	1010	0.24	0.43	0	1
Dum 1997-2002	1010	0.71	0.45	0	1

TABLE 4: MULTINOMIAL PROBIT REGRESSION – ENTRY IN SEMICONDUCTOR PRODUCT CATEGORIES

VARIABLES	Coefficients		
	(1) Standardized vs. Other	(2) Customized vs. Other	(3) Customized vs. Standardized
Spin-off	0.4889 [0.1827]***	0.0456 [0.1525]	-0.4431 [0.1771]**
Demand Start-up	0.5394 [0.1905]***	0.3089 [0.1579]**	-0.2305 [0.1814]
Firm size	0.0123 [0.0054]**	0.0296 [0.0049]***	0.0172 [0.0047]***
Fabless firm	0.5461 [0.1466]***	0.0726 [0.1296]	-0.4735 [0.1347]***
Serial entrepreneur	0.0822 [0.1662]	0.0470 [0.1434]	-0.0352 [0.1546]
Dum 1997-2002	0.4324 [0.1633]***	-0.0260 [0.1343]	-0.4585 [0.1550]***
Constant	-1.6589 [0.2382]***	-0.5171 [0.2064]***	1.1417 [0.2229]***
Log Likelihood		-958.7707	
Chisq		83.99***	
Observations		1010	

Heteroskedastic robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

TABLE 5: MULTINOMIAL PROBIT REGRESSION – MARGINAL EFFECTS

	Marginal Effects		
	Standardized	Customized	Other
Pr(PRODUCT =j 1 selected)	0.1746	0.5553	0.2698
<i>Spin-off</i>			
Predicted for Spin-off = 0	0.140	0.572	0.287
Predicted for Spin-off = 1	0.234	0.523	0.242
Absolute change	0.094	-0.049	-0.045
Relative change	67.1%	-8.57%	-15.7%
<i>Demand Start-up</i>			
Predicted for Demand start-up = 0	0.152	0.545	0.303
Predicted for Demand start-up = 1	0.222	0.567	0.210
Absolute change	0.070	0.022	-0.092
Relative change	46.0%	4.03%	-30.4%
<i>Firm size</i>			
Predicted at 30 th percentile	0.175	0.551	0.273
Predicted at 70 th percentile	0.173	0.559	0.267
Absolute change	-0.001	0.007	-0.006
Relative change	-0.61%	1.27%	-2.20%
<i>Fabless firm</i>			
Predicted for Fabless firm = 0	0.136	0.572	0.273
Predicted for Fabless firm = 1	0.238	0.524	0.259
Absolute change	0.102	-0.048	-0.054
Relative change	75.0%	8.39%	-19.8%
<i>Dum 1997-2002</i>			
Predicted for Dum 1997-2002 = 0	0.118	0.594	0.286
Predicted for Dum 1997-2002 = 1	0.201	0.536	0.261
Absolute change	0.083	-0.058	-0.025
Relative change	70.3%	-9.76%	-8.74%

TABLE 6: COMPLEMENTARY LOG-LOGISTIC REGRESSIONS FOR THE PROBABILITY OF EXIT. BASE MODEL

	(1)	(2)	(3)	(4)
Constant	-3.874 [0.277]***	-4.280 [0.321]***	-4.319 [0.327]***	-4.295 [0.326]***
Time (Log)	-0.152 [0.073]**	-0.151 [0.073]**	-0.147 [0.074]**	-0.147 [0.073]**
Spin-off	-0.420 [0.155]***	-0.443 [0.155]***	-0.481 [0.159]***	-0.466 [0.162]***
Demand Start-up	-0.562 [0.164]***	-0.579 [0.164]***	-0.583 [0.163]***	-0.567 [0.166]***
Firm size		0.013 [0.004]***	0.012 [0.004]***	0.013 [0.004]***
Fabless firm			0.216 [0.135]*	0.227 [0.137]*
Serial entrepreneur				-0.186 [0.168]
Dum 1997-2002	1.221 [0.254]***	1.171 [0.253]***	1.157 [0.253]***	1.144 [0.252]***
Observations	6845	6845	6845	6845
Number of positive outcomes	238	238	238	238
log likelihood	-1009.21	-1004.14	-1002.82	-1002.16
Chi-square	50.35***	61.38***	63.14***	65.77***

Heteroskedastic robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

**TABLE 7: COMPLEMENTARY LOG-LOGISTIC REGRESSIONS FOR THE PROBABILITY OF EXIT.
PRODUCT MARKET CATEGORY AS MODERATOR**

	(4)	(5)	(6)
Constant	-4.295 [0.326]***	-4.619 [0.310]***	-4.903 [0.325]***
Time (Log)	-0.147 [0.073]**	-0.152 [0.073]**	-0.137 [0.073]*
Spin-off	-0.466 [0.162]***		
Demand Start-up	-0.567 [0.166]***		
Entry in Standardized		0.265 [0.303]	
Standardized x Spin-off		-0.671 [0.385]*	
Standardized x Demand Start-up		-0.208 [0.381]	
Entry in Customized			0.944 [0.177]***
Customized x Spin-off			-0.465 [0.195]**
Customized x Demand Start-up			-0.764 [0.205]***
Firm size	0.013 [0.004]***	0.012 [0.004]***	0.010 [0.005]**
Fabless firm	0.227 [0.137]*	0.203 [0.133]	0.226 [0.137]*
Serial entrepreneur	-0.186 [0.168]	-0.227 [0.165]	-0.227 [0.165]
Dum 1997-2002	1.144 [0.252]***	1.187 [0.250]***	1.197 [0.251]***
Observations	6845	6845	6845
Number of positive outcomes	238	238	238
log likelihood	-1002.16	-1007.056	-994.279
Chi-square	65.77***	44.64***	82.83***

Heteroskedastic robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1