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We provide empirical evidence on market positioning by firms, in terms of market niche, distance from technological frontier and dispersion. We focus on the switch industry, a sub-market of the Local Area Network industry, in the nineties. Market positioning is a function of the type of firms (incumbents versus entrants), market size and contestability and firm competencies. We find that incumbents specialise in high-end segments and disperse their product in a larger spectrum of the market. Instead, entrants focus on specific market niches. Market size, market contestability and firm competencies are also important determinants of product location.

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1. Introduction

This paper analyses market positioning by firms, in terms of market niches, distance from the technological frontier and dispersion. It explores whether the strategy of market positioning differs between incumbents and entrants and whether it depends on the nature of the competition and firm capabilities.

The empirical work focuses on the switch industry, a sub-market of the Local Area Network (LAN) industry in the 1993-1999 period. During this period, the switch market has experienced a rapid and sustained growth accompanied by new product entry due mainly to a very fast rate of technical change. We employ data from an original dataset of LAN equipment and firms, consisting of 704 new products marketed between 1993 and 1999. We develop indicators of distance among firms in the product space, product dispersion and distance of firms from the quality frontier. These indicators are then regressed against a set of explanatory variables, which aim to capture the nature of the competition and firm capabilities.

The paper is structured as follows. Section 2 reviews some of the existing literature on product differentiation. Section 3 provides some background information on the technological evolution of the switch market and Section 4 describes the indicators and the variables that are used in the empirical work. Section 5 presents the result and provides interpretation in terms of the nature of the competition and firm capabilities. Section 6 concludes and highlights the limitations of the analysis.

2. The Determinants of Product Differentiation

Economic theory looks at product differentiation as a means for firms to compete on other grounds than mere price competition, allowing them to enjoy Schumpeterian rents from their temporary monopoly. In itself, product differentiation is usually analysed in terms of location in a product and / or characteristics space. If prices are given, then the traditional Hotelling (1929) results hold according to which, in equilibrium, firms tend to locate products 'back to back' in the middle of a linear product spectrum. If however firms first locate and then compete in prices, there is the tendency to locate products away from each other (Shaked and Sutton, 1982).

Two main factors influence product differentiation: the size of the product space and market contestability. When the size of the product space is large, firms attempt to appropriate parts of the demand, which is left unsatisfied, by entering into unexplored segments of the market. Conversely when size is given, market contestability prevails. High contestability implies that the threat from potential entrants may persuade incumbents to introduce close substitutes for existing products in order to prevent firm entry. Incumbents with high market shares are likely to suffer from market contestability more than other firms because of the reduction in demand for existing product resulting from the introduction of their own substitutes. This phenomena has been referred to as cannibalisation (Spence, 1976; Eaton and Lipsey, 1979).

Evidence in favour of cannibalisation is unclear. In the ready-to-eat cereal industry, incumbents have been found to employ product proliferation strategy to fill existing niches before entrants (Schmalensee, 1978). Looking at the PC industry over the 1981-1992 period, Bayus and Putsis (1999) found no evidence of such a strategy. The reasons for this mixed evidence are at least twofold. First, the extent of firm product diversification is likely to affect the choice of location. Product diversification in other markets may be a better strategy than proliferation when firms have not yet diversified (Bonanno, 1987; Bhatt, 1987) in order to spread their risky activities in several markets. Second, product introduction as analysed by economic theory has put much emphasis on where firms are driven to by factors such as market size and contestability. It has questioned less the capacity of firms to introduce innovative products in specific segments. Arguably, firm competencies as a whole may be powerful determinants of product location, other than market size and contestability. This has been repeatedly argued by the resource-based theory of the firm (Penrose, 1959) in general, and the evolutionary theory of the firm in particular.

The evolutionary theory of the firm (Nelson and Winter, 1982) is grounded on the very idea that firms make what they can rather than making what they want. This is due to the fact that the accumulation of productive knowledge is highly path dependent. Newly acquired knowledge at any point in time is a function of the firm knowledge base accrued in previous periods. As a result, knowledge accumulation takes inherently the form of successive small steps on related technological competencies rather than the form of stochastic moves across unrelated technological competencies (Teece, et al., 1994; Breschi et al., 2003). More generally, the evolutionary theory of the firm puts much emphasis on the fact that firms are composed of heterogeneous knowledge and competencies, the exploitation and exploration of which is non-random and non-obvious, but above all non-immediate.

An additional argument for bounded opportunities for firms rests on the idea that the product space is inherently rugged (Levinthal, 1997). This is due to the fact that technologies form complex systems, that is, product components cluster around specific product architectures and a change in one the component may imply changes in other components within the architecture or changes in the architecture itself (Henderson and Clark, 1990). Thus, what could appear as a small move for the firm may embody radical alterations of its technical competencies. In this context, previous experience with a specific market and / or technology may also be a source of organisational inertia. It may also prevent established firms from understanding emerging customer needs and enter into new markets (Christensen and Rosenbloom, 1995). Technology race models predict that incumbents enjoy either an advantage over entrants (Gilbert and Newberry, 1982) or a disadvantage (Reinganum, 1983) depending on whether the design of new products represents incremental improvements of existing ones or a radical departure respectively.

The above implies that the mere identification of a new market opportunity represents only half the challenge. Firms must be able to modify their limited range of productive capabilities in order to introduce a supposedly more successful product. They do this in various ways: by renewing their human capital; by investing in new, more productive equipment; by undertaking systematic research activities; by identifying new suppliers or partners; by exploiting their complementary assets in a novel or more efficient way (Teece, 1986; Mitchell, 1989). For example, production and sales experience in existing markets provide firms with the possibility to compete efficiently in a related market niche by reducing entry costs (Klepper and Simons, 2000; King and Tucci, 2002). Within this context, incumbents may have advantages over entrants. In her study of product location in the PC market, Stavins (1995) finds that established firms disperse more their products along the spectrum benefiting from learning and economies of scope. Looking at the automobile industry, Thomas and Weigelt (2000) find that incumbents and large firms use their experience to locate new products close to their existing ones and away from those of the rivals.

On the basis of the above discussion, we expect product location to reflect the nature of the competition, i.e. the size of the product space and market contestability, but also firm capabilities. In particular, we expect incumbents to have followed a segmentation strategy and move incrementally in the product space. This is because incumbents can rely on past experience, leaving entrants to fill more distant and less crowded niches. However, we expect incumbents to produce a larger product line and disperse their products in the product space more than entrants to possibly deter entry. Finally, we expect incumbents that produce close substitutes to locate in the high-end segment where customer preference for availability of complementary products, post marketing assistance and availability of continuous training tends to protect them from competition from new firms. Entrants would instead focus on new customers and locate their products in the low-end segment.

3. The Dynamics of the LAN Industry

We study the strategy of location in the product space by incumbents and entrants in the switch market. Switches are part of the infrastructure that constitutes Local Area Networks (LANs). Together with other types of equipment with which they have to interoperate they are employed by users to send and receive data packets. Switches were introduced in the context of data communication in 1990, first as a solution to congestion problems that existing equipment (i.e. hubs) could not deal with. Switches experienced a rapid diffusion in the first half of the last decade mainly as a consequence of the expansion of local networks and subsequently of the early diffusion of client server architectures within firms.

LANs are technical systems made up of different components (both hardware and software) that are combined to form an infrastructure to enable users located physically close to one another to send data and/or share common resources such as printers and other types of peripherals. Within the system, different types of equipment ensure that data transmission occurs: hubs that broadcast the data to many users located within a specific segment; switches that send data only to the user(s) that is supposed to receive it; routers which are able to choose the shortest path to destination and embed additional management and security functions that switches do not have. In addition to the equipment, communications standards set the ‘rules’ and the speed at which data transmission occurs.

There are four different phases in the evolution of the LAN industry, each of them characterised by the introduction of new key equipment and the establishment of one or more specific communication standards.[1] The first phase, from the mid-1970s to mid-1980s, is characterised by the absence of an official communication standard and the presence of many proprietary solutions marketed by different manufacturers. The second phase, from the mid 1980s until the end of the decade, saw the introduction of hubs and the official standardisation of Ethernet and Token Ring as communication standards.[2] Hubs were introduced mainly to offer a unique point of concentration within firms in order to rationalise the cabling system. The third phase from the end of the 1980s until mid 1990s, witnessed the growth of the hub market and the establishment of Ethernet as the dominant communication standards for LANs. As more and more nodes were added to the LAN, congestion increased revealing the shortcomings of hubs in solving new bottlenecks.[3] The introduction of the switch and the emergence of Fast Ethernet as the high-speed upgrade of Ethernet characterise the fourth phase. From the technological viewpoint, early switches possessed higher port density (i.e. they could connect more nodes)

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[1] For the period breakdown we follow Christensen *et al.* (1995)

[2] Ethernet was originally developed at the Menlo Park Research Labs in the first half of the 1970s and had become the standard chosen by Xerox for its internal network. Token Ring was the standard of choice for IBM based networks. Other proprietary standards existed (i.e. ARCnet and StarLAN). See von Burg (2001)

[3] See Fontana (2003) for an account of the main events that characterised the battle of standardisation of new high-speed standards.

than hubs and were capable of forwarding data very fast and only to those nodes that were necessary, therefore helping to reduce network congestion. Although more expensive than hubs, switches provided users with additional features.

Interestingly, the emergence and development of switches coincided with the entry of three types of manufacturers. First, incumbents from within the LAN industry (both from the router and the hub market). Cisco, the future dominant firm in the switch market, came from the router market and was among the early firms to enter. More hesitant incumbents in the hub market (3Com, Bay Networks, DEC) were constrained by their previous investments as well as by the risk of cannibalising their installed base.[4] Second, incumbents from outside the industry but with previous experience either in the telecom industry or in the semiconductor industry. Third, start-ups searching for new opportunities, especially when the outcome of the battle for standardisation was still surrounded by uncertainty.

The growth of the switch market is related to the developments in the equipment design. The first was the change in the design of the equipment following the transition to RISC and ASICs based architectures that occurred in the middle of the 1990s. This development enabled high economies of scale to be obtained in the production of switches and to achieve higher forwarding speed, support more nodes and reduce delays in transmission. The second was support for new functionalities that improved data management and made switches more sophisticated and similar to routers. As a result of these events, in the second half of the 1990s, two segments opened up in the switch market. The high-end switches, characterised by high port

[4] Threatened by new competition, hub manufacturers responded with a strategy of incremental improvements to existing product architectures to manage the transition to the new phase. However, this strategy based on the modular upgrading of existing equipment proved ineffective to contrast the diffusion on switches. Brusoni and Fontana (2004) provide a detailed analysis of the benefits and shortcoming of this strategy.

density and high performance, are targeted to customers with large networks. The low-end switches are low cost and generally less performing, support only one standard and are targeted to customers with small networks.

Importantly, the nature of the competition in the two types of market segments is different. In the low-end segment, manufacturers compete mainly on price. In the high-end segment, competition is usually influenced by the presence of substantial switching costs for customers. Switching costs derive mainly from the need to purchase equipment that is compatible with existing switches, and from the cost of learning to use equipment purchased from different manufacturers. Since communication standards are open, in theory customers can mix-and-match equipment from different manufacturers in the same network. However, switches need software programmes to function and manufacturers often design proprietary software that makes the equipment incompatible with that of other manufacturers.[5] This practice has implications both for adoption choice and the strategy of product introduction by manufacturers.

On the demand side, previous investments in both hardware and software of specific manufacturers gives a strong incentive for users to continue to buy compatible equipment from the same manufacturer, in order to avoid incurring the extra costs of switching. In a survey of the determinants of switch choice by users, Forman and Chen (2004) find evidence that the presence of an installed base of equipment from a particular manufacturer increases the likelihood of repurchasing from the same vendor if the customer decides to buy again. These issues become particularly important in the case of technologically sophisticated equipment such as high-end

[5] This is the case for instance of the Spectrum network management software developed by Cabletron, the Cisco Fusion architecture first and then the Internet Operating Systems (IOS) software developed by Cisco (Gawer and Cusumano, 2002).

switches used in large networks of hundreds to thousand of users. Within these networks, costs for moving and adding new users are very high. Connecting and setting-up new configurations as well as troubleshooting are particularly complicated and software that works for specific equipment may not work with others (Christensen *et al.*, 1995).

On the supply side, manufacturers can exploit the presence of high switching costs to lock-in customers and compete against rivals. Relying on an existing installed base, manufacturers may strategically set the timing of new product introduction in order to force customers to buy upgrades. Moreover, manufacturers tend to introduce families of products that work well together. These families typically include devices of different densities, configurations and supporting different communication standards so as to be able to target the entire demand spectrum (i.e. going ‘end-to-end’) and/or to prevent rivals from entering specific niches. All major manufactures in the switch industry followed this strategy.[6]

The structure of the switch market has always been concentrated although less than that of other markets within the LAN industry (i.e. routers). In 1994, the four biggest firms in the market (Cisco (Kalpana), 3Com (Synernetics), Alantec and Chipcom) accounted for 94% of revenue share. In the 2nd quarter of 1999, the last year of our sample period, the share of the four biggest companies had fallen to 81% with Cisco maintaining the lead at 47%, followed by 3Com, Nortel Networks (Bay Networks) and Cabletron.[7]

[6] In 1994 Cisco offered the first product of its Catalyst line of Switch equipment that will be enriched in the following years by many other high-end as well as low-end equipment. 3Com responded with the Superstack and Office Connect line of equipment, the former targeting big users, the latter customers with smaller networks. Also the other two big incumbents, Bay Networks and Cabletron, marketed an entire product line, the BayStack and Smartswitch respectively.

[7] Sources: The Yankee Group (Network World: October 31, 1994). 1999 (2qt): Dell’Oro Group (Network World: October 18, 1999: p.30)

4. Data and Measurements

The data used in this paper consist of information on product characteristics and prices of switches and hubs. They come from an original dataset of 1071 LAN products (535 hubs and 536 switches marketed between 1990-1999 and 1993-1999 respectively). The dataset was constructed using information from specialised trade journals (*Network World* and *Data Communications*) that periodically publish details on new product introductions. This information has also been double checked, whenever possible, with press communications and product announcements released by manufacturers themselves.

In the original dataset there are 199 different manufacturers. For the purpose of our analysis, we decided to consider only those manufacturers who marketed four or more products in the period 1990-1999. After consolidation we were left with 82 firms and a subset of 704 products in total (464 switches and 240 hubs). As we can determine product location only when firms do innovate, the number of observations in the sample, i.e. firms introducing at least one product for a given year in the switch market, is 176.

For each product the dataset reports information on its technical characteristics, date of market introduction and list price. The chosen time span fully covers the year of development and growth of the switch market as well as the years of consolidation and decline of the hub market. By stopping in 1999 this analysis only partially accounts for the most recent period of the evolution of the switch market characterised by the entry of telecom companies. Since most of these firms produce for the high-end part of the market our data may lead to an underestimation of the impact of entrants on the location in this segment.

Figure I shows the pattern of new product introduction for both switches and hubs between 1993 and 1999.

{Figure I Approximately Here}

Dependent variables

We represent the location of product in a vertical or horizontal space using the generic technological characteristics of the products in the switch market and measuring distances across products. There is no authoritative way of measuring distances across products. The most challenging aspect of this analysis is deciding how products can be benchmarked. Following Stavins (1995), we do it in two steps.

In the first step, we reduce the multi-attribute structure (the technological characteristics) to a single dimensional measure of product quality. Assuming independence across product technological attributes, we project them onto a linear scale as follows:

$$q_m = \sum_{l \neq k}^{D} \beta_j \cdot z_{jm} \tag{1}$$

Eq.(1) suggests that the quality q of model m can be measured as the weighted sum of its characteristics. The weights $_j$ represent the marginal value of characteristics j that both consumers and producers place on the j^{th} attribute. Such weights $_j$ are approximated by regressing observed prices, deflated into 1996 US dollars using the Implicit Price Deflator provided by the U.S. Department of Commerce, Bureau of Economic Analysis, on product characteristics:

$$\ln(P_{mit}) = \alpha + \alpha_t + \sum_j \beta_j \cdot z_{jm} + \varepsilon_{mit} \tag{2}$$

where α is a constant and α_t is a time fixed effect. Table I provides the results from the hedonic regression. With 70% of the variance of prices explained, the overall fit is satisfactory enough although a substantial part of the observed prices (30%) is due to factors other than those introduced in the regression. This may in turn be due to omitted product attributes and erroneous pricing reflecting changes in demand.

{Table I Approximately Here}

In Table I, the estimated weights are constrained to be constant over time, whereas the technology in the Switch market is likely to have evolved over time. This suggests that depending on significant changes in product quality in the nineties, the pooled regression may produce inexact weights. We performed separate hedonic regressions in order to test for parameter equality over time by means of a Chow test. All years differ significantly and thus separate hedonic regressions were performed to produce $_{jt}$ instead of $_{j}$. These are used to calculate *q*, the predicted price by hedonic regressions. Whereas the observed prices embody error measurements reflecting various factors such as changes in demand, promotional discounts and other non-quality components (see Stavins, 1995), the predicted price *q* reflects by construction the quality of the product. Ranking these prices is tantamount to ranking products according to their quality.

In the second step, we use the predicted price *q* to compute distances across product. We start by considering horizontal product differentiation by computing the mean Weitzman distance d^{c}_{mit} of a given model *m* from all models introduced the previous year:

$$d^{c}_{mit} = \frac{\sum_{n-1}^{N_{t-1}} \sqrt{\left(q_{mit} - q_{n,t-1}\right)^2}}{N_{t-1}} \tag{3}$$

where N_{t-1} is the number of products at year *t* - 1, q_{mit} is the quality of model *m* by firm *i* in year *t* and $q_{n,t-1}$ is the quality of model *n* in year *t* – 1. This product space can be thought of as a circle in which products locate. The further from centre *c* of the circle, the more peculiar the product is from the representative product. Because firms can introduce several products in a given year, we calculated for every firm and every year the average distance $\overline{d}_{it}^{c}$. Alternatively, we use the predicted price *q* to rank products on a vertical product space. To do so, we compute for every product its distance from the *quality* frontier as follows:

$$d_{mit}^{f} = \max(q_{it}) - q_{mit} \tag{4}$$

where q_{mit} is the quality of model *m* by firm *i* in year *t*. The higher d_{mit}^{f}, the farther the product is from the quality frontier. Again, because firms can introduce several products in a given year, we computed for each firm the lowest distance from the technical frontier $d_{it}^{f} = \min\left[d_{mit}^{f}\right]_{it}$.

The last measure deals with product dispersion in order to test the proposition that incumbents spread their product over a wider range of the product space. We develop a measure of product dispersion in two steps (Stavins, 1995). In the first step, we construct a measure of product dispersion within the firm:

$$\sigma_{it} = \frac{\sum_{m=1}^{M_{it}} (q_{mit} - \overline{q}_{it})}{M_{it}} \quad \text{where} \quad \overline{q}_{it} = \frac{\sum_{m=1}^{M_{it}} q_{mit}}{M_{it}} \tag{5}$$

In turn for a given year, the overall product dispersion is defined as:

$$\sigma_{t} = \frac{\sum_{n=1}^{N_{t}} (q_{nt} - \overline{q}_{t})}{N_{t}} \quad \text{where} \quad \overline{q}_{t} = \frac{\sum_{n=1}^{N_{t}} q_{nt}}{N_{t}} \tag{6}$$

The relative dispersion index is defined as the ratio of the two dispersion measures σ_{it} and σ_{t}:

$$R_{it} = \frac{\sigma_{it}}{\sigma_t} \qquad (7)$$

Figure II plots the mean relative dispersion index by firm age. It seems that firm age between 2 and 6 years on the switch or hubs market does not impact on the dispersion of the product. However widening the age range from 1 to 7 years suggests a positive and non-linear relation between firm age and product dispersion.

{Figure II Approximately Here}

Independent variables

Consistent with the empirical literature, we distinguish between entrants and incumbents as a main determinant of innovative strategies for product location. Additionally, we argue that product location is a function of two main factors: the nature of the competition and firm capabilities. We decompose the notion of competition into two components: the size of the product space and market contestability. First, like Khanna (1995), we use Eq.(4) to develop a measure of the size of the product space as follows:

$$\text{Size of the Product Space} = \frac{\sum_M \left(\max(q_{it}) - q_{mit}\right)^2}{M} = \frac{\sum_M \left(d^f_{mit}\right)^2}{M} \qquad (8)$$

where M is the number of products at year $t-1$ and q_{mit} is the quality of model *m* by firm *i* in year *t*. Eq.(8) has the lowest value of zero, which in this case means that the average distance is null and that all products introduced in a given year compete with the same characteristics. This measure is also informative about the intensity of the competition between firms. With a shrinking measure, the market is concentrating around a dominant quality and thus firms compete in a narrower product space. With a growing measure, the market is expanding with the introduction in the product space of novel product quality.

{Figure III Approximately Here}

Figure III plots the computed measures of the product space for both the hub and switch markets. We observe two successive waves: the hub market, after having expanded until 1995, has been constantly concentrating around a narrower technological space; the switch market is still expanding, thus leaving room for potential entrants to enter into the market. This is in line with our appreciative knowledge that the former is technologically older than the latter. Second, we develop a measure of market contestability as follows:

$$\text{Market Contestability} = \frac{E}{F} \qquad (9)$$

where E and F are the number of entrants and the total number of firms, respectively. This represents an *ex post* measure of market contestability based on the entrant counts, as opposed to *ex ante* measures such as, for example, barriers to entry. When the number of entrants is high, the ratio (E/F) is high and therefore, market contestability is supposedly high. This variable varies between 0 and 1. A value close to unity indicates high contestability by entrants, whereas a low value indicates low contestability.[8] Figure IV plots the accumulated number of firms F and the number of entrants E per year. The number of entrants increase until 1995 and drop to zero in 1998 stabilising the number of firms in the switch market to around 80 from 1997 onwards.

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[8] We do not have information on product and / or firm exit, so that the number of firms does not account for manufacturers who decided to leave the industry. As a consequence, this variable may overestimate the effect of barrier to entry on our indicators of product location.

{Figure IV Approximately Here}

Before turning to the issue of measuring firm capabilities, it is interesting to graph the number of product innovations by types of innovator (see Figure V). It shows that rapidly, incumbents play a major role in innovative activities in the switch market, since from 1995 onward, most innovations were introduced by firms competing on the switch market for at least a year.

{Figure V Approximately Here}

Firm capabilities range from technological competencies to capabilities in complementary activities such as distribution and commercialisation. We measure these capabilities with the number of years for which the firm has been active in the switch market. Arguably, this should control for firm experience in both core competencies and complementary assets. In a similar fashion, we test the presence of economies of scope by controlling for firm experience in the hub market. Firms may benefit from their experience in distinctive yet related markets, which in turn may potentially influence the capacity of firms to enter and locate in particular segments of the switch market.

6. Results

We model product location in terms of distance from market centre, distance from technological frontier and dispersion as a function of the nature of the competition (technological competition and barriers to entry) and firm experience in the Switch (incumbents versus entrants and firm experience in the switch and hub markets). Additional explanatory variables are included to control for a time trend and firm fixed effects. The results of OLS regressions are displayed in Tables II to IV. In each model, we use several specifications to control for the robustness of the results.

Because of the small number of observations (N = 176 for Tables II to IV) and the unbalanced nature of the panel, the inclusion of firm dummy variables is limited to those firms innovating for at least five years.

Table II presents the results of the analysis of product location in the switch market. Five models have been estimated using the mean Weitzman distance as a dependent variable. In each of the proposed models we sequentially introduce a new set of independent variables. Model (1) only takes into account whether the firm has previously introduced a switch while models (2) and (3) look at the impact on firm location choice of technological competition, marker structure and previous experience in the switch and / or the hub market. We find a negative and significant coefficient of the incumbent variable suggesting that established firms tend to locate their new products close to existing ones.

{Table II Approximately Here}

In model (2) we introduce the variables of the nature of the competition: the size of product space and market contestability. We lag these variables one period in order to account for their influence at the time when firm decisions occur. The positive and significant sign of the former suggests that, as the product space expands, firms introduce less close substitutes for existing products. In a context of expanding opportunities for product location this strategy is consistent with entry deterrence behaviour as predicted by Brander and Eaton (1984). Consistent with the result of Stavins (1995), market contestability enters positively, suggesting that the threat of new entrants leads firms to saturate the product space by locating new products far from existing ones. These results hold after controlling for additional factors such as firm capabilities (Model 3), time trend (Model 4) and unobserved heterogeneity between the most innovative firms (Model 5).

In model (3) we look at the influence of previous experience in the same and / or related markets and technologies. The coefficient of Experience in Switch is positive although not significant, whereas the coefficient of Experience in the Hub market is negative and significant. This suggests that the more experience firms have in this related market the more they tend to locate their switches in crowded areas of the product space. Previous experience in a related market reinforces a segmentation strategy in the switch market using their existing distribution channels, assistance and training to serve the new customers. Moreover, for a hub maker, producing switches means producing a distant substitute for their products. The choice of locating close to other switch manufactures could be the consequence of a strategy aimed at filling empty spaces before competitors do in order to preserve customers.

Overall, these results show that established firms cluster their products in a relatively narrow and crowded portion of the product space (they segment). It implies that firms do not expect intense price competition either from existing rivals or from entrants given that, by producing more distant substitutes for existing products, incumbents might effectively deter entry by new firms. We question whether, in a context of market expansion, this type of behaviour depends on the pattern of demand and the presence of high switching costs for users. If there are different categories of customers who, as argued in Section 3, have to sustain high costs of switching between manufacturers, then location in the product space becomes less a strategic decision for incumbents. Firms may produce close substitutes without worrying about price cuts from rivals or increasing competition from entrants.

Table III displays the results of the determinants of location in the vertical product space. Here the dependent variable is the lowest distance of each firm from the quality frontier (d_{it}^{f}), whereas the set of independent variables is identical to that of

Table II. Model (7) looks at the influence of the type of innovator and market structure on firm location. The sign of Incumbents is negative and significant, suggesting that established firms locate close to the frontier, i.e. incumbents target the high-end of the market, whereas entrants produce for the low-end. The sign of Incumbents does not change when controlling for other factors although it becomes insignificant (Models 8 to 10).

The negative and significant coefficient of Size of Product Space indicates that the expansion of the product space increases technological opportunities to locate new products close to the frontier (i.e. target the high-end market). The negative and significant coefficient of Market Contestability suggests instead that the threat from entrants leads firms to locate far from the frontier (i.e. target the low-end market). Overall, these results depict a situation in which opportunities to cater for high-end customer increase as the market grows but are seized mainly by incumbents. Since incumbents tend to segment, as shown in Table II, we conclude that they tend to cluster their products mainly in the high-end segment.

{Table III Approximately Here}

Results from models (6) and (7) suggest that entrants target mainly low-end customers, implying that entrants do not leapfrog incumbents. The reasons for this are threefold. First, because incumbents saturate high-end segments of the market, there is little demand left for entrants. Second, evidence on adoption behaviour in the switch industry shows that unattached users focus on the low-end segments (Forman and Chen, 2004). Third, as argued in Section 3, the presence of barriers to entry in the form of economies of scale in production discourages new firms from entering at all in the market. The above remarks are reinforced when we focus on firm experience in the switch – and related – markets.

Experience in Switch has a negative sign suggesting that as experience grows incumbents continue to focus on the high-end segment, whereas Experience in Hub is positive and significant, indicating that the higher the previous experience in the hub market the more firms position their products far from the frontier. These results are in broad agreement with the evolutionary theory of the firm, where the distinctive skills of firms in a high technology industry such as the switch market are related to their core technological competencies. Moreover, although hub makers could leverage on complementary assets, they did not possess the required technological competencies to manufacture high-end products.

Finally, we analyse product innovation in terms of product dispersion. Table IV presents the results of the *Relative Dispersion Index* (*RDI*, Eq. 7) as a function of the type of innovator, the nature of the competition and firm experience. Most coefficients are not significant, the most robust result being the positive and significant sign of Incumbents across all the models (11)-(15). This suggests that incumbents disperse their products more than entrants. It is consistent with the presence of demand side switching costs that give an advantage to firms who market full product lines. Market Contestability has a negative sign suggesting that the threat from entrants provides impetus for incumbents to saturate the product space and engage in several segments of the market. This result is consistent with those of Table II where we argued that the presence of many firms in the market reduces the space for locating new products and reduces the incentive to disperse new models.

{Table IV Approximately Here}

Finally, we note that none of the variables capturing firm experience on product dispersion are significant.[9] This result suggests the absence of learning effects in explaining the behaviour of incumbents and reinforces the evidence that dispersion is mainly a consequence of the presence of demand side switching costs.

7. Conclusion

This paper has investigated the determinants of product location in the switch equipment industry. Two issues have been at stake: whether firms followed a specific strategy when introducing a new product; and whether previous experience with the same and/or related technology influenced the location decision. Concerning the first point, our analysis found that incumbents and entrants followed different product location strategies. We did not find evidence of a strategic pre-emptive behaviour by incumbents, such as entering empty market niches. On the contrary, the overall results of the analysis of product location with respect to competing firms suggest that in this market incumbents have a tendency to segment. We also found that incumbents tend to segment in a specific portion of the switch market, namely the high-end. We interpret this evidence on the basis of the presence of demand side switching costs that shelter firms from (the reaction of) rivals and competition from entrants. The influence of demand side switching costs on product location choice is confirmed also by the choice of incumbents to disperse their product more in the product spectrum (i.e. they introduce wide product lines). Instead, entrants disperse less.

[9] One could argue that the reason for the non-significance of the variables related to firm capabilities is its co-linearity with the variable "Incumbents". These results hold even when regressing *RDI* on firm capabilities only.

Concerning the second point, we found mixed evidence on the role of past experience on firm location choice. On the one hand, previous experience gained in related markets reinforces segmentation, especially in the case of firms targeting the low-end of the market. On the other hand, previous experience acquired in the same market does not affect the choice of product location. There seems to be a discontinuity in location in the high-end segment. Being an incumbent represents an advantage, but this advantage does not depend on past experience.

Overall, our results indicate that the nature of competition differs whether you are an entrant or an incumbent. For entrants, competition consists of a succession of *moves*, aimed at climbing the ladder from the low-end to the high-end segments. In order to reach the top-end of the market, a firm must accumulate experience first, being active in another related market for instance, and exploit it subsequently. For incumbents, competition consists in securing their *position*, by occupying the high-end of the market first and then saturating the product space. These types of behaviour coexist and plead in favour of the idea that firm type and, albeit in a less systematic way, firm capabilities also explain product location. Other strategic determinants of firm location such as market contestability and market size, although important, do not seem to be equally relevant to explain product differentiation in this industry.

The results of this paper capture stylised facts emerging from empirical analyses of the evolution of the switch industry. Although they are still preliminary, they are consistent with some of the predictions of the existing theoretical literature on product location (Brander and Eaton, 1984) and entry deterrence in the presence of switching costs (Klemperer, 1995; Farrell and Shapiro, 1988). Finally, they also point to the importance of firm resources and capabilities in determining location choice and of market competition in boosting technical change.

Our results are subject to a number of limitations, mainly related to a lack of additional information on switch products. The most immediate is the absence of data on product sales. From the econometric viewpoint, the above estimations should weight each observation, i.e. product, by its sales. From the theoretical viewpoint, product sales provide firms with market power, which in turn should prove influential in their strategy. The other issue concerns product exit. In markets where exit is frequent, market structure is highly affected by product exit. Our study should extend the analyses of product location to product exit, as is the case in Stavins' (1995) analysis. The combined availability of product sales and exit would enable us to study the relationship between product location and product sales and exit. The last limitation concerns the difficulty to gather additional information on firms themselves in order to measure firm competencies in a more articulated way. Future work will explore ways of connecting unsystematic yet existing financial data on firms with information on firm patenting activity. Although challenging, the connection of these various datasets with the one explored in this paper should prove particularly fruitful in elucidating product location in highly turbulent markets.

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FIGURE I
NUMBER OF PRODUCT INNOVATIONS IN THE SWITCH AND HUB MARKETS

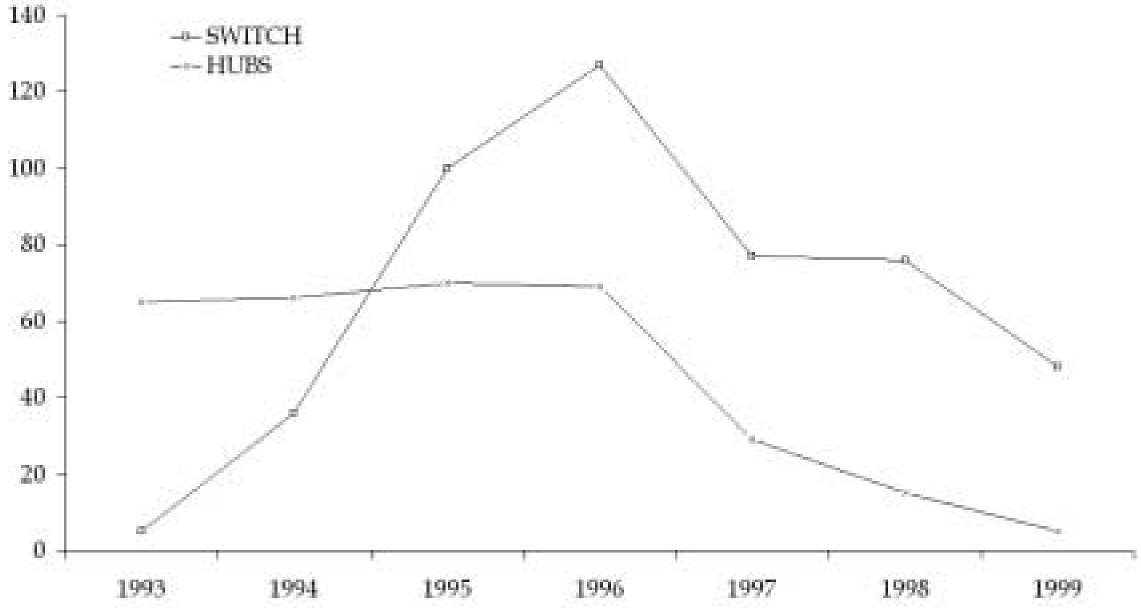

FIGURE II
DISPERSION OF MODEL QUALITY BY FIRM AGE IN THE SWITCH AND HUB MARKETS

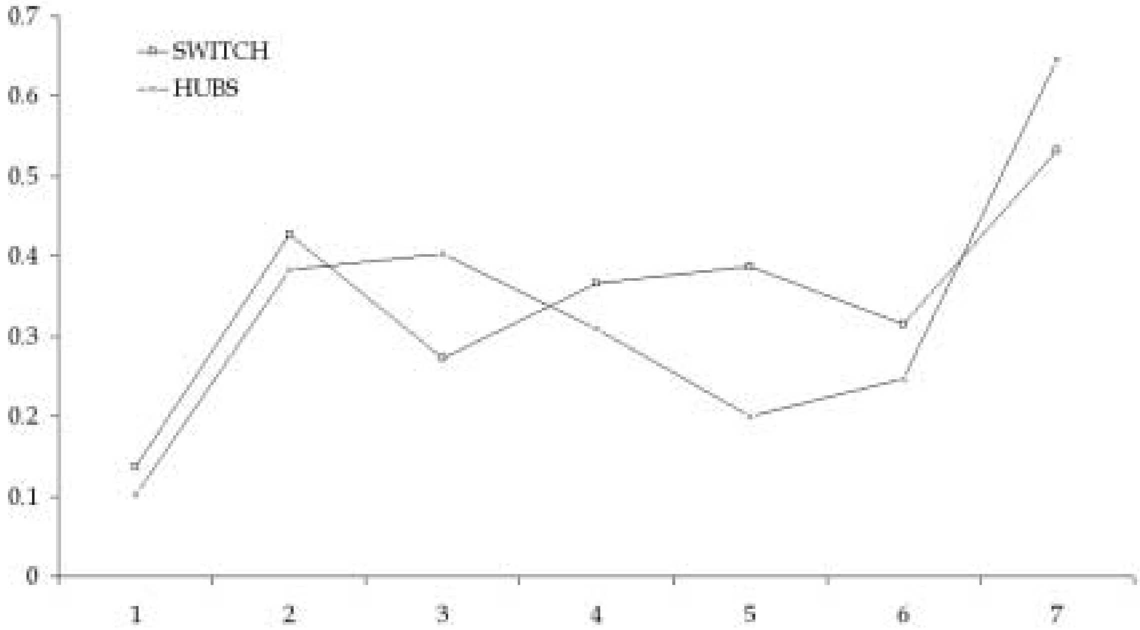

FIGURE III
SIZE OF THE PRODUCT SPACE IN THE SWITCH AND HUB MARKETS

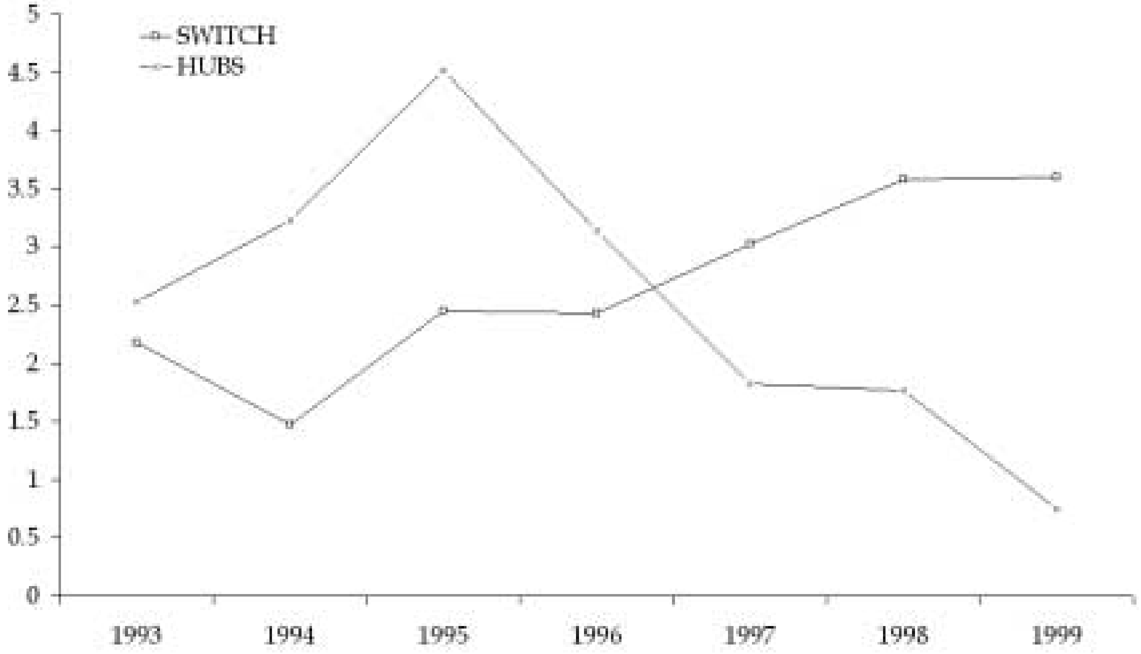

FIGURE IV
NUMBER OF FIRMS AND ENTRANTS IN THE SWITCH MARKET

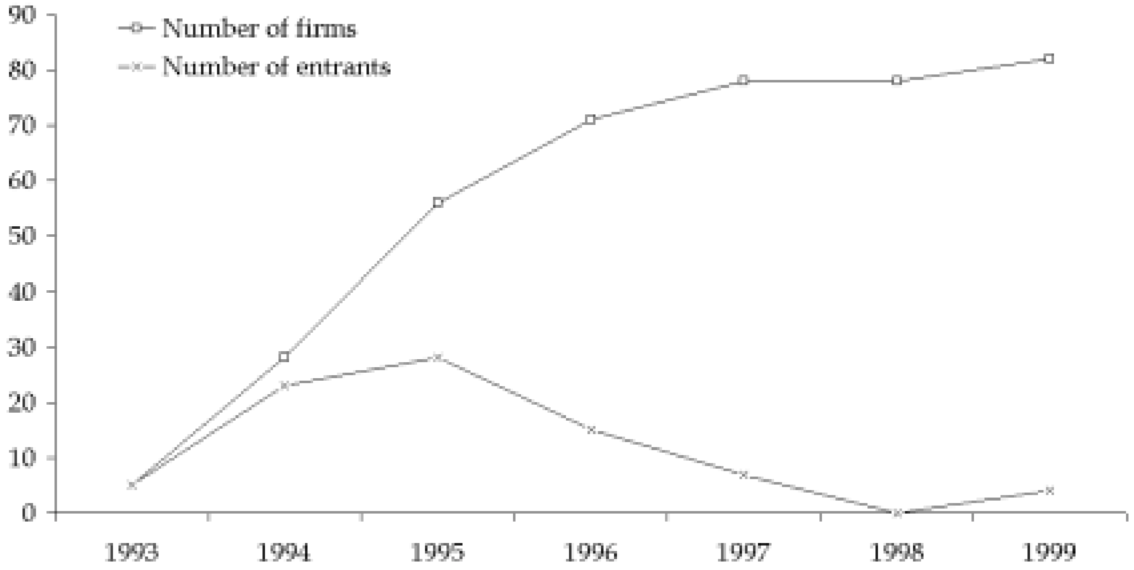

FIGURE V
NUMBER OF PRODUCTS INTRODUCED BY ENTRANTS OR INCUMBENTS IN THE SWITCH MARKET

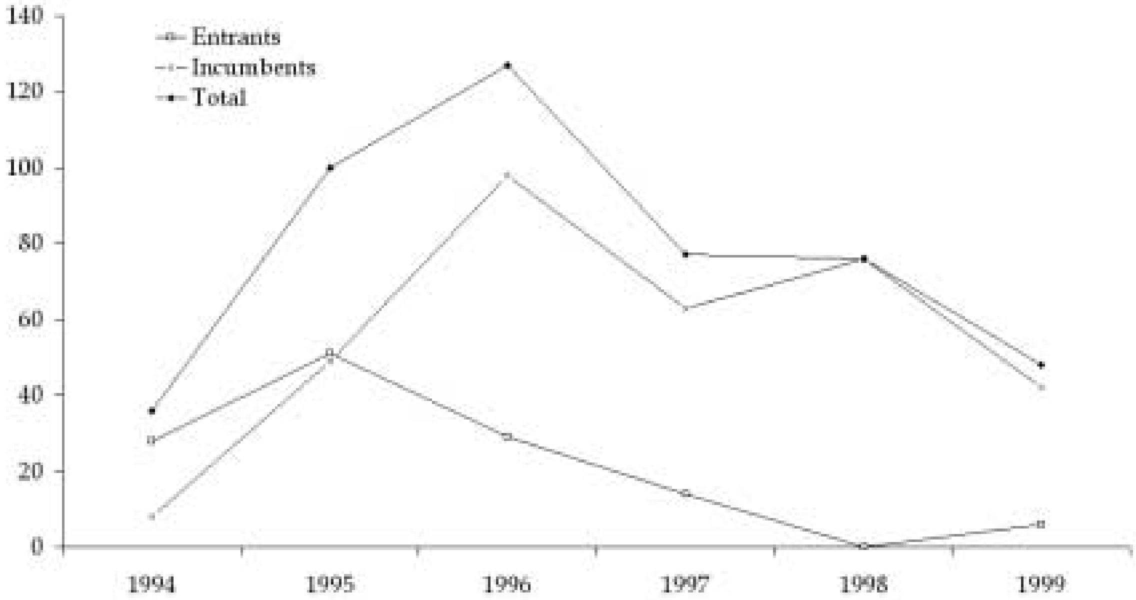

TABLE I
ORDINARY LEAST SQUARES REGRESSION ON HEDONIC PRICES
DEPENDENT VARIABLE: DEFLATED PRODUCT PRICE

Backplane Capacity	0.239 [0.038]***
Number of Ethernet Ports	0.088 [0.029]***
Number of Fast Ethernet Ports	0.029 [0.038]
Number of FDDI Ports	0.030 [0.060]
Number of Token Ring Ports	0.129 [0.045]***
Number of 100VG-AnyLAN Ports	0.259 [0.109]**
Number of ATM Ports	0.120 [0.044]***
Number of Gigabit Ethernet Ports	0.361 [0.058]***
VLANs Capability	0.313 [0.107]***
Modular Configuration	0.906 [0.136]***
Fixed Configuration	-0.208 [0.094]**
Intercept	8.044 [0.438]***
Observations	469
R-squared	0.687
Log-L	-558.4

Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%
Year dummy variables omitted for clarity.

TABLE II
ORDINARY LEAST SQUARES ON THE LOCATION OF INNOVATIONS IN THE SWITCH PRODUCT SPACE
DEPENDENT VARIABLE: MEAN WEITZMAN DISTANCE.

	(1)	(2)	(3)	(4)	(5)
Incumbents	-0.118 [0.069]*	-0.196 [0.085]**	-0.256 [0.114]**	-0.193 [0.109]*	-0.172 [0.109]
Size of Product Space (t – 1)		0.255 [0.103]**	0.241 [0.097]**	0.196 [0.088]**	0.198 [0.089]**
Market Contestability (t – 1)		0.090 [0.204]	0.082 [0.211]	1.295 [0.645]**	1.311 [0.653]**
Experience in Switch			0.059 [0.062]	0.033 [0.059]	0.012 [0.070]
Experience in Hub			-0.046 [0.023]**	-0.049 [0.024]**	-0.040 [0.028]
Trend				0.311 [0.144]**	0.321 [0.153]**
Firm Fixed effect	No	No	No	No	Yes
Observations	176	176	176	176	176
R-squared	0.017	0.099	0.126	0.163	0.189
Log-L	-105.5	-97.8	-95.1	-91.4	-88.5

Intercept not reported. Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE III

ORDINARY LEAST SQUARES ON THE LOCATION OF INNOVATIONS IN THE SWITCH PRODUCT SPACE

DEPENDENT VARIABLE: DISTANCE FROM QUALITY FRONTIER

	(6)	(7)	(8)	(9)	(10)
Incumbents	0.035 [0.196]	-0.477 [0.219]**	-0.328 [0.275]	-0.309 [0.281]	-0.352 [0.275]
Size of Product Space (t – 1)		-0.570 [0.261]**	-0.544 [0.248]**	-0.558 [0.241]**	-0.539 [0.233]**
Market Contestability (t – 1)		-2.264 [0.494]***	-2.190 [0.499]***	-1.812 [1.542]	-1.744 [1.533]
Experience in Switch			-0.187 [0.114]	-0.195 [0.115]*	-0.086 [0.129]
Experience in Hub			0.189 [0.058]***	0.189 [0.058]***	0.242 [0.061]***
Trend				0.097 [0.354]	0.045 [0.353]
Firm Fixed Effect	No	No	No	No	Yes
Observations	176	176	176	176	176
R-squared	0.000	0.129	0.182	0.183	0.298
Log-L	-291.7	-279.6	-274.0	-273.9	-260.6

Intercept not reported. Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

TABLE IV
ORDINARY LEAST SQUARES ON THE DISPERSION OF INNOVATIONS IN THE SWITCH PRODUCT SPACE
DEPENDENT VARIABLE: RELATIVE DISPERSION INDEX

	(11)	(12)	(13)	(14)	(15)
Incumbents	0.221 [0.065]***	0.250 [0.090]***	0.246 [0.119]**	0.292 [0.121]**	0.327 [0.123]***
Size of Product Space (t – 1)		-0.003 [0.094]	-0.006 [0.097]	-0.039 [0.098]	-0.044 [0.095]
Market Contestability (t – 1)		0.084 [0.157]	0.095 [0.165]	0.982 [0.576]*	0.961 [0.587]
Experience in Switch			-0.005 [0.044]	-0.024 [0.048]	-0.089 [0.060]
Experience in Hub			0.014 [0.022]	0.012 [0.022]	-0.009 [0.025]
Trend				0.227 [0.146]	0.255 [0.150]*
Firm Fixed effect	No	No	No	No	Yes
Observations	176	176	176	176	176
R-squared	0.053	0.056	0.058	0.075	0.191
Log-L	-112.6	-112.3	-112.1	-110.5	-98.7

Intercept not reported. Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%