1. Introduction

The role of information in high-technology markets is critical (Dutta, Narasimhan and Rajiv 1999; Farrell and Saloner 1986; Weiss and Heide 1993). In these markets, the volatility and volume of information present managers and researchers with the considerable challenge of monitoring such information and examining how potential customers may respond to it. Furthermore, since high-technology markets are dynamic and characterized by a high degree of uncertainty, information related to them changes rapidly and requires continuous tracking (Glazer 1991). The potential difficulties in collecting, classifying and tracking critical market information may explain why the dynamics of such information and, more importantly, its effects on market response have remained relatively unexplored (Gatignon and Robertson 1985; Rogers 1976; Rosa et al. 1999).

In this article, we study the effects of various types of information on the market share of different technological standards in the Local Area Networks (LAN) industry. We focus on market stories as the main source of information for this market (see also Theoharakis and Wong 2002). These stories provide information about technologies, products, benefits, limitations, usage conditions, or market dynamics in published media, such as industry and trade journals, newspapers, and consumer magazines. Thus, it can be said that they represent the information shared among actors in a market system, comprising of producers, customers, dealers, market analysts, and journalists (Mayzlin 2002; Weick 1995). Our choice to focus on market stories found in trade media is consistent with past marketing literature that describes print media as the most influential source in high involvement and industrial markets (Robertson, Eliashberg and Rymon 1995). It is also in accordance with the work of sociocognitivists that place a great deal of emphasis on print media as sensemaking vehicles for explaining evolution of products and markets (Weick 1995; White 1981). In our case, we disaggregate into story types the market information found in more than 10,000 articles that appeared in related trade publications over a span of twenty years (1981-2000). We then develop hypotheses on how the volume of each type of information can influence the market share of a technological standard and test them using a multiplicative market share model.

The rest of the paper is organized as follows. The next section provides the conceptual background of the study discussing how the different types of information can capture the dynamics of a technology. In the third section, we develop and state the hypotheses regarding the effects of information on market share. In the fourth section, we provide a description of the data and measures used while in the fifth section we discuss the econometric model and present the estimation results. The final section carries the managerial implications and conclusions of the study.

2. Conceptual Background

We follow an evolutionary approach to studying the effects of information on market shares of technological standards. The evolutionary approach can be justified on the basis that high-tech markets are dynamic causing information regarding new technologies[1] to change rapidly. Thus, changes in the types of information concerning new technologies can signify changes in their evolution. Following Theoharakis and Wong (2002), we identify three types of information that

[1] For the remainder of the article we will use the terms “technologies” and “technological standards” interchangeably.

are expected to capture the evolution of a technology: *Technological*, *Availability* and *Adoption*[2]. Technological information focuses primarily on the technical aspects and potential of the technology (e.g. standards setting activities, technology features). It basically conveys the changes that the technology is undergoing and market participants seek to understand prior to adopting the technology. Naturally, a large volume of technological information may indicate a considerable effort in the basic development of technological standards suggesting an uncertain market environment as the technology remains immature. Product Availability information is mainly concerned with new products supporting the specific technology (e.g. product launch announcement, product tests). Similarly to advertising, product availability information represents the voice of suppliers that announce new products supporting the standard. Finally, the primary focus of Product Adoption information is the adoption of products based on the particular technology. This type of information is typically presented in the form of adoption case studies (e.g. Company X adopted standard Y).

Theoharakis and Wong (2002) found that the relative volume of technological information is higher in the early stages of the technology's evolution, availability information increases as products supported by the technology are introduced and the relative volume of adoption information increases when customers initially purchase the new products available in the market. They further showed that high technology market information progressed from a technology intensive stage (technical stories dominate), to a supplier push stage (nearly a balance of product availability and technical stories) and then to a product focus stage (dominance of product availability stories). We therefore expect that at any given time, the relative volume of a particular type of information (technological, availability, adoption) should communicate to the market the stage of a technology's evolution. Once the stage of technology evolution is communicated to the market through the relative volume of each type of information, we anticipate that the market (customers) will respond accordingly. For example, we expect higher market response in the post-launch stages of a technology, as communicated through a high volume of availability and adoption types of information, rather than in the pre-launch stage as communicated through a high volume of technological type of information. But we also expect differences between the effects of availability and adoption information on market response. These expectations are elaborated and summarized in the form of hypotheses in the ensuing section.

3. Hypotheses Development

As a new technology emerges, prior to the availability of products supporting this technology, engineering efforts are intense (Popper and Buskirk 1992) and the market seeks to classify the new technology by understanding its technical capabilities and positioning it within the context of existing technologies. At this stage, the volume of technological stories is high as the market seeks to "make sense" out of the new technology and enhance its knowledge regarding the technology characteristics (Theoharakis and Wong 2002). Because the technology is at an early stage of its cycle, uncertainty is high (Lieberman and Montgomery 1988; Wernerfelt and Karnani 1987) and products supported by the technology tend not to be available. In such a case, the

[2] There was a fourth category in the referenced study- discontinuation information. As this type of information is a direct consequence of the (poor) market performance of a standard it was believed that it could not affect performance. Indeed preliminary analysis showed that discontinuation information did not significantly affect market share.

market will prefer to focus more on collecting information on the characteristics of the new technology, rather than adopting it. Thus, when the relative volume of technological stories is high the share of the technological standard is expected to be low as uncertainty regarding the technology is high and the availability of products is limited. Our first hypothesis is therefore formulated as follows:

H1: **The relative volume of technological stories is negatively related to the market share of a technological standard.**

Product availability is necessary for the adoption of a new technology – if products supporting the technology are not available, the market has nothing to respond to. The presence of products supporting the technology indicates that suppliers have developed and are actively marketing such products. Information regarding the availability of products based on the technology should reduce uncertainty (Gatignon and Robertson 1991), as availability stories communicate to the market that the technology is implementable and has successfully made a transition from a "hype" or promise stage to a reality (delivery) stage. Therefore, increased availability information should lower market uncertainty about the technology and encourage potential customers to adopt it. We thus form our second hypothesis:

H2: **The relative volume of product availability stories is positively related to the market share of a technological standard.**

Imitation is considered as an important driver for the adoption of a new product or technology (Bass 1969). Higher volumes of adoption information indicate that more customers have adopted the technology. Adoption information should reduce uncertainty for potential customers as they learn more about the technology through the adoption cases of other firms (Kapur 1995). When the relative volume of adoption information therefore increases, more potential customers should become convinced about the use and applications of the technology and would tend to imitate earlier adopters (Geroski 2000). Thus, product adoption information should reduce the uncertainty of potential customers as it communicates the usefulness of the technology to them, and ultimately leads to a positive response to the technology. We therefore propose the following hypothesis:

H3: **The relative volume of product adoption stories is positively related to the market share of a technological standard.**

Once the adoption of technologies starts, potentially adopting firms may observe the decisions of early adopters and use such observations as information to make their own adoption decisions. In other words, it is likely that potential customers substitute adoption information available by the trade journals with their own observations of competitors and partners that have already adopted a technology. On the other hand, it is less likely that availability information is substitutable since the fact that products supporting the technology are available does not necessarily imply that the market adopts them. This suggests that availability information would be more critical for the performance of a standard due to its low substitutability. Thus, for a given volume we expect that the effect of availability information should be higher than the effect of adoption information leading to our final hypothesis:

H4: **For a given volume, the effect of availability information should be higher than that of adoption information.**

4. Data and variables

It has been suggested that the emerging information and communications industry provides an interesting laboratory for testing strategies in dynamic environments (Chakravarthy 1997). Our empirical application focuses on the Local Area Networks (LAN) industry. A LAN consists of components that form the data communications infrastructure of an organization within the geographical boundaries of a building or a campus. LANs have enabled the free flow of information across coworkers and form the information backbone of the modern firm. Over the last two decades, several LAN technologies have been introduced with varying degrees of success, while demand and requirements for data networking continued to increase. We consider the five LAN technologies (Ethernet, Token Ring, FDDI, ATM and PC Network) that were discussed in the media and for which market share data were available. More specifically, Ethernet has become the dominant LAN technology, while in the late 1980's Token Ring managed to achieve a market share of more than 30%. Although FDDI was initially expected to connect every desktop, in the early 1990's it became the technology of choice for the connection of servers and high-end workstations. On the other hand, ATM and PC Network were technologies that received considerable market story attention but did not manage to achieve high market shares.

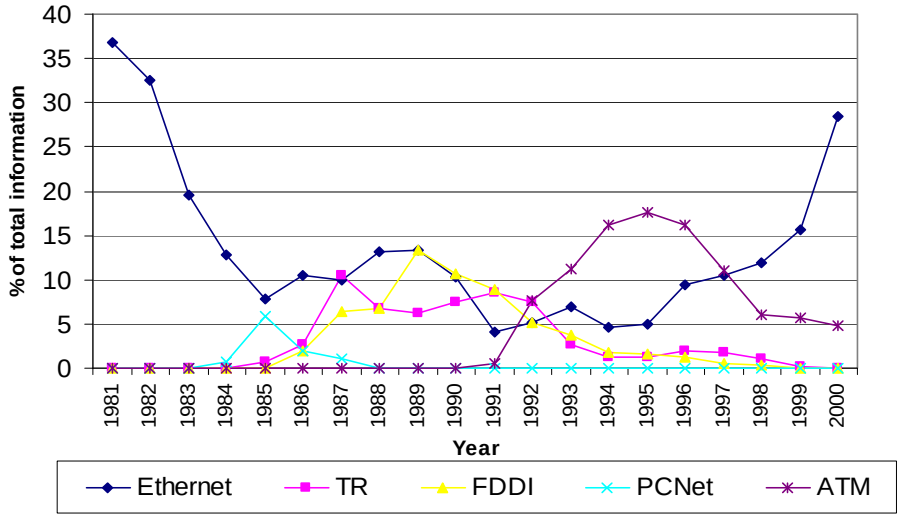
Consistent with past literature on measuring public attention or estimating the domination and displacement of different subject matters over time (Altheide 1996; Krippendorff 1980), we use quantitative content analysis for monitoring the volume and type of market information. The enormous volume of information exchanges that takes place in a market necessitates the sampling of relevant and available sources. Based on interviews with five industry experts (sales and marketing managers in three LAN supplier companies), and two different industry surveys (Corbo and Villars 1994; EuroLAN 1996), print media (trade journals) were identified as the most important source of information in the LAN industry (Theoharakis and Wong 2002). Given the large number of trade journals and other print media, it was important to select the ones with the highest impact and which would be available for the creation of a longitudinal study. The ABI/Inform database contains substantive abstracts from more than 800 sources but more importantly, includes four out of the top five publications (based on circulation) for the two relevant Business Publications Association International (BPA) subcategories for the LAN industry (computer and telecommunications). Although the Internet has increased in importance as a communications medium, these trade journals remain relevant as their printed content is available online free of charge. We tracked references to all LAN technologies, based on 10,412 relevant article abstracts in the focal journals for the 20-year period between 1981 and 2000. We then classified the information conveyed for all relevant technologies in each article in one of the predefined story types.

A technology's annual market share is measured by its share of worldwide sales of network interface connections for Personal Computers (IDC 1987-2000). Network interface cards (NICs) support only one technology and are what is required to connect a PC to a LAN-reflecting therefore a firm's decision to adopt a particular standard. Since standards are

incompatible with each other[3], firms typically commit to only one standard. NIC market shares therefore, can accurately reflect the success of a LAN standard benchmarked against the competition. The relative volume of each type of information is measured as the annual share of each story type over the total number of stories for all technologies. Thus our measure of relative volume benchmarks each standard's type of information both against the other types of information for the same standard and against the competition. Using a measure of information benchmarked against the competition is important since our market performance measure (market share) is also relative to competition.

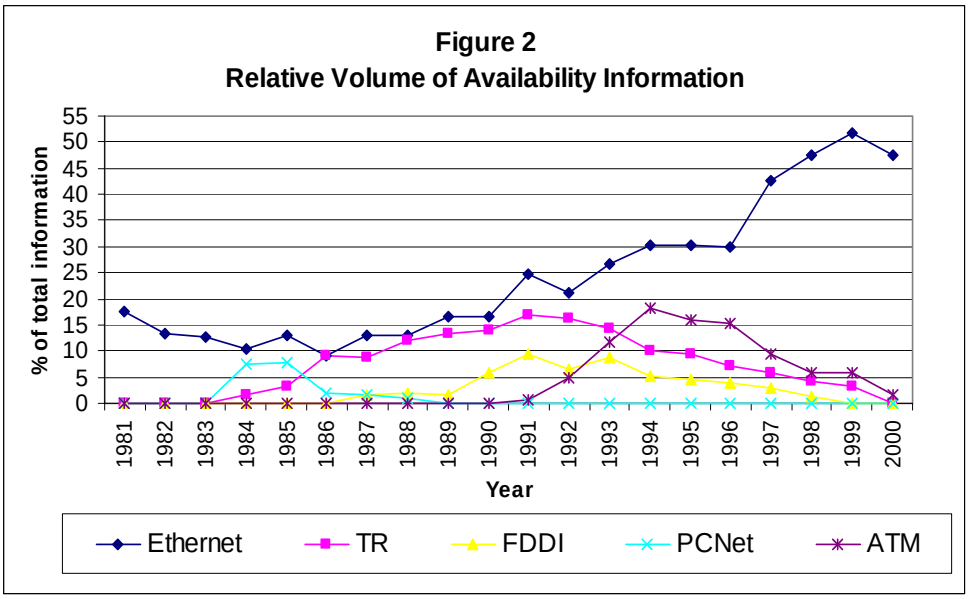
Relative volumes of Technology, Availability and Adoption information for the five LAN standards are shown in Figures 1-3[4]. While we analyzed market information of all LAN technologies for a 20 year period, our model's application was limited to years for which market share data were available (IDC 1987-2000).

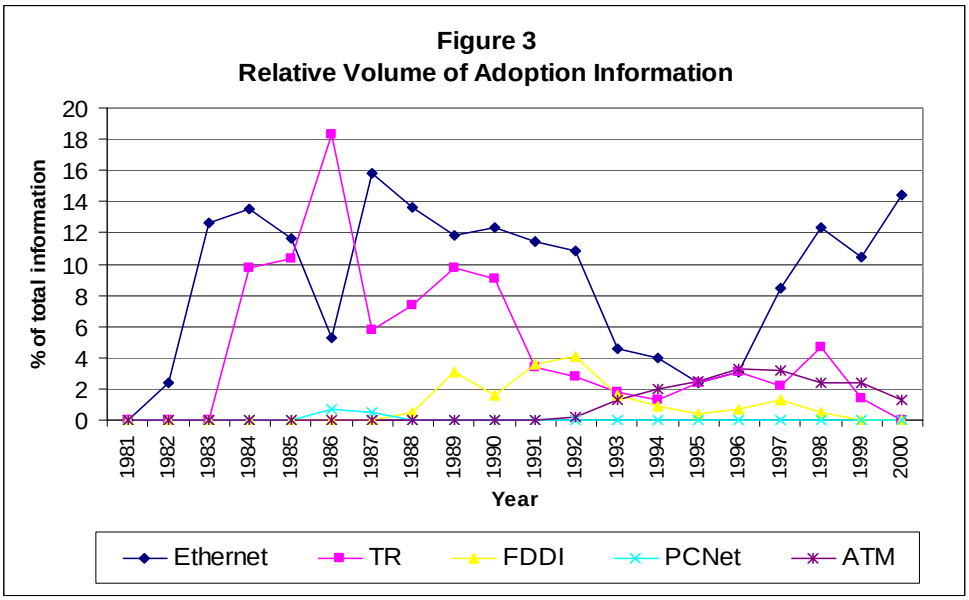
Figure 1
Relative Volume of Technology Information



[3] Special equipment is required to interconnect networks supporting different standards.

[4] Although the relevant volume of technology information is expected to be low in the advanced stages of a standard's evolution, it is high for Ethernet in the year 2000 (Figure 1) due to its eventual emergence as the dominant standard.





4.1 Model Specification

We employ a multiplicative model to study the effects of information on the shares of LAN standards. Multiplicative specifications are frequently used in marketing studies to model market share (see, for example, Hanssens, Parsons and Schultz 2001). Since the multiplicative model specifies a log-linear relationship between market share and its explanatory variables, it circumvents problems arising from the constraint that market share should be between 0 and 1[5].

[5] Alternatively we could have used a logically consistent MCI model that constrains market shares to add up to 1. However, the requirement of the MCI model that one standard should serve as the "baseline" would have reduced the power of our results due to the limited number of available observations (50).

It also allows for the highest order of interaction among the explanatory variables. More specifically we propose the following model:

$$MS_{it} = e^{\alpha_i D_i + \frac{\beta}{T_{it}}} ARV_{it-1}^{\gamma} PRV_{it-1}^{\delta} TRV_{it-1}^{\eta} e^{\varepsilon_{it}} \quad (1)$$

where:

i=1,..,5 is an index for the standard with i=1 indicating Token Ring (TR), i=2 indicating Ethernet, i=3 indicating FDDI, i=4 indicating ATM, i=5 indicating PCNET.

D_i = Dummy variable taking the value of 1 for standard i and zero otherwise for i=1,…,4 with PCNET (i=5) being the "baseline" standard.

T_{it} = Time in market for technological standard i at time t.

MS_{it} = Market share for technological standard i, at time t

ARV_{it-1} = Relative volume of availability information for technological standard i, at time t-1

PRV_{it-1} = Relative volume of adoption information for technological standard i, at time t-1

TRV_{it-1} = Relative volume of technology information for technological standard i, at time t-1

Where the measures used for the market shares and relative volume of information are as defined in the Data and Variables section. The technology-specific intercepts (α_i) capture potential unobserved and intangible effects of the various technologies[6]. We include lagged rather than current information effects since current information appearing in the trade journals may also reflect the market performance of a particular standard, leading to causality problems[7]. The time-in-market variable captures the growth a standard may experience due to time effects (evolution). The particular exponential specification ensures that for large values of time in market, market share reaches a plateau. We expect positive growth due to time thus a negative β.

The model was estimated using an ordinary least-squares approach. The results appear in Table 1. The adjusted R-squared is 0.96 suggesting a very good fit of the model to the data. The coefficients of the explanatory variables are all significant suggesting that information-related variables contribute considerably to the model fit. Also the signs of the information-related parameters have the expected direction, confirming therefore hypotheses H1-3. More specifically the technological information coefficient is negative and significant whereas both the availability and adoption information coefficients are positive and significant. Furthermore, the availability information coefficient is larger than that of the adoption information coefficient suggesting that H4, which was based on the rationale that availability information is less substitutable than adoption information, could not be rejected. Only the dummy variables corresponding to Ethernet and Token Ring (TR) are positive and significant suggesting that these two types of standards show effects that extend beyond the information-related and time variables. Ethernet and Token Ring were also the top two standards in the market in terms of share. Finally, as expected, the time-in-market coefficient is negative and significant at the 10% level suggesting that the longer the presence of a standard in the market the higher its performance, albeit such relationship is weak. The relatively weak contribution of time in market to the performance of a

[6] A random intercepts model was also estimated but it did not improve the fit of the standard-specific intercepts model.

[7] We thank a reviewer for pointing this issue to us.

standard suggests that growth may not be attributed to time alone, rather the different types of information (the volume of which varies over time) appear to track market share performance better.

Table 1
Multiplicative Share Model Results

Variable	Coefficient	t-value
TR Intercept (α_1)	2.58	4.80
Ethernet Intercept (α_2)	2.43	3.57
FDDI Intercept (α_3)	-0.66	-1.05
ATM Intercept (α_4)	-0.86	-1.10
Time-in-Market (β)	-1.98	-1.73
Availability Information (γ)	1.44	3.20
Adoption Information (δ)	0.86	4.43
Technology Information (η)	-0.66	-2.49
No. of Observations	50	
Adjusted R-square	0.96	

5. Managerial Implications and Conclusions

Researchers have consistently pointed out the importance of information for the market success of a new technology. The existence of the appropriate information in high-tech environments can lead to uncertainty resolution and potentially grant a competitive advantage to firms. In this article we distinguish among different types of information and develop hypotheses concerning their effects on market share. We found that there are not only volume but also content effects of information on market share. In fact, a potentially useful result for managers is that not all types of information translate into a competitive advantage. More specifically, we found that technology-related information is negatively related to the market share of products supporting a technology standard as it demonstrates that the underlying technology is immature and still evolving.

We also found that the effects of adoption and product availability information on market share, although both positive, do not have the same impact. The effect of availability information is higher than that of adoption, all other things being equal. We attribute this difference to the possibility that once early adoption of a technology occurs, potentially adopting firms may observe decisions of early adopters and use such observations as an additional source of information to make their own adoption decisions. It is therefore likely that potential customers

substitute adoption information appearing in the trade journals with their own observations of competitors and partners who have already adopted a technology since these two basically communicate the same message - the market has started adopting the technology. On the other hand, it is less likely that availability information is substitutable since information that products supporting the technology are actually available does not necessarily communicate that the market has already adopted the technology. Thus, managers should place considerable emphasis on the dissemination of availability information through appropriate press releases and publicity to communicate the critical fact that the technology has made the transition from the promise (hype) to the reality phase. This means that however innovative a new technology might be, without the appropriate (availability) information, it may risk missing the opportunity of achieving a higher share. Consequently, especially at the early stages of a technology's life cycle, managers cannot rely on the expectation that the "product will sell for itself." The phase where the "product sells for itself" would only come when the technology establishes a record of adoption cases enabling communication of benefits to potential customers through the observation of early adopters (Kapur 1995).

In this study we used share as the measure of market response to information in order provide a sense of how information can help a technological standard establish its position relative to the competition. The eventual success and domination of Ethernet in the LAN market can be at least partly attributed to the effects of information as suggested by our empirical results. Another interesting subject of research would be to examine the role of information on the diffusion of a technological standard. Such a study would shed light on whether and how information can shape the sales *evolution* of a technological standard, a line of inquiry not pursued in this study. Given the great importance of information for the diffusion process (Horsky 1990; Rogers 1983) it should be worthwhile investigating the exact mechanism of its influence.

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7. Colophon

Vasilis Theoharakis
The Athens Laboratory of Business Administration (ALBA)
Athinas & Areos 2A
Vouliagmeni, Athens
Greece 166 71
+30 210 8964531
vtheohar@alba.edu.gr

Demetrios Vakratsas
Faculty of Management
McGill University
1001 Sherbrooke St. West
Canada H3A 1G5
demetrios.vakratsas@mcgill.ca

Veronica Wong
Aston Business School
Aston University
Aston Triangle
Birmingham B4 7ET
United Kingdom
v.w.y.wong@aston.ac.uk