Research Policy xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

# Technological leadership and persistence in product innovation in the Local Area Network industry 1990–1999

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ARTICLE INFO

*Article history:*
Received 6 October 2014
Received in revised form 24 March 2016
Accepted 15 April 2016
Available online xxx

*Keywords:*
Product innovation
Persistence
Technological leadership

ABSTRACT

We study how technological leadership affects persistence in product innovation. Relying upon a database of 1818 products marketed between 1990 and 1999 by 265 firms active in three markets of the Local Area Network (LAN) industry we first construct a measure of technological leadership and then relate this measure to persistence in innovation. We find that controlling for size, R&D intensity, intangible assets, and market structure, technological leaders are more persistent innovators than laggards. We also find that leaders in one market can also systematically innovate in a related and adjacent market.



## 1. Introduction

The issue of the determinants of persistence in innovation has been on the agenda of researchers on economics and innovation for quite some time. Early works have highlighted that prior innovative activity alone is a good predictor for the length of the innovative spell and have looked at innovation in terms of intermediate outputs such as patents (Cefis and Orsenigo, 2001; Cefis, 2003). More recent works have looked at innovation persistence using indicators of innovative inputs such as R&D expenditures (Peters, 2009; Máñez et al., 2015). Other works have instead measured persistence in terms of process and product innovation (Raymond et al., 2010; Clausen et al., 2012; Triguero and Córcoles, 2013). Most of these prior works have started from the assumption that, although firms are heterogeneous in terms of their propensity to innovate, persistence in innovation might result from a series of determinants ranging from the presence of learning effects associated to innovative activity (Atkinson and Stiglitz, 1969), broadening of the horizon of technological opportunities and re-investment of extra-profits (Mansfield, 1968; Nelson and Winter, 1982), and/or constraints to the re-organization of the innovative activity in terms of sunk costs (Dasgupta and Stiglitz, 1980; Sutton, 1991).

This paper focuses on persistence in product innovation. We argue that an additional, albeit neglected, determinant of persistence in product innovation is *technological leadership* defined in terms of a firm's relative position with respect to the technological frontier. Specifically, we contend that in industries characterised by rapid technical change and shortening of product life cycle, such as the one analysed in this study, technological leadership leads to specific product innovation strategies. These strategies may entail an extension of the technological frontier, changes in product portfolio through product proliferation, and extension of product portfolios through innovation in related markets. Differences between technological leaders and laggards will lead to the pursuit of different innovation strategies and ultimately translate into differences in persistence in innovative output.

We examine the relationship between technological leadership and persistence in product innovation in the context of the Local Area Networking (LAN) industry. Our source of information is a comprehensive database of 1818 new products marketed between 1990 and 1999 in three LAN markets: hubs (536 products), routers (747 Products), and switches (535 products). For each product in our dataset we have information on: year of market introduction, technical characteristics, market price, and name of the manufacturer. Our dataset includes 265 firms. These firms constitute the *population* of innovators in the LAN industry in the period under analysis here. For each firm in the dataset we have collected information about date of entry into the industry, size in terms of employees, R&D expenditures, and sales when available. In addition to these data we have also collected information on the patenting

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http://dx.doi.org/10.1016/j.respol.2016.04.002
0048-7333/

activity of the firms included in our sample. In particular, by looking at the (8 digits) International Patent Classification (IPC) class of the patents we have been able to link patents to innovative activity in each specific market.

Using these data we carry out the following analyses. First, we employ information on product characteristics and price to compute an indicator of technological leadership in each market. Here we proceed in two steps. For each market, hedonic price regressions are estimated and predicted prices are calculated. Predicted prices are then used to compute a measure of technological frontier and calculate the relative distance of each firm from the frontier. Second, we use this indicator to distinguish between technological leaders and laggards and produce Transition Probability Matrices (TPMs) to study persistence in product innovation for both types of firms. Third, we perform Conditional Risk Set Duration analysis to study the determinants of the probability to innovate in each period conditional on firms' initial innovative status and technological leadership in the prior period. Our covariates include an indicator of technological leadership, as well a series of firm and industry level controls such as R&D intensity, firm size, age, possession of intangible capital in terms of patent stock, and market structure. Particular attention is devoted to estimating cross market effects (i.e. to study the impact of technological leadership in one market on persistence in another market) for multi-product firms.

Our main result is that, controlling for R&D intensity, size, age, prior patenting activity and market structure, technological leaders are relatively more persistent innovators than laggards. The closer a firm is to the technological frontier at $t$ the higher the probability to commercialise a new product in the next time period, though the marginal effect of changes in distance from the frontier varies across markets reflecting different levels of technological opportunities. Another important result is that technological leaders in one market can also systematically innovate in a *related and adjacent* market. Technological laggards instead are not able to innovate in related markets.

Our research provides the following contributions. First, it directly relates persistence in product innovation to an indicator of technological leadership at the firm level. This fills an important research gap as prior studies have instead focussed on other firm characteristics such as R&D expenditures, size, and/or age. Our findings show that even when controlling for these characteristics, technological leadership is a key determinant of persistence. Second, our findings are based on micro-level data on product innovation over time. This is a crucial improvement with respect to existing empirical research on persistence in product innovation that have mainly relied upon 'coarse' aggregate indicators of product innovation such as 'product new-to-the-firm or new-to-the-market' taken from surveys. Third, our findings highlight the link between technological leadership and persistence in product innovation in related markets suggesting that technological leaders can pursue persistence following different innovation strategies.

The paper is structured as follows. In Section 2 we review the literature on persistence in innovation and propose our framework for analysis. Section 3 introduces some necessary background information on the LAN industry. Section 4 presents our data and method. Section 5 introduces our empirical strategy. Results are presented in Sections 6 and 7. Section 8 concludes.

## 2. Background literature

Research on persistence in innovation has a long tradition in the field of innovation studies. Three groups of empirical contributions can be identified: studies of persistence in innovation inputs; studies of persistence in intermediate innovation outputs (i.e. patents); studies of persistence in innovation outputs (i.e. products). In this section we propose a non-exhaustive review of the main contributions in each of these fields.[1] Then we focus on the relationship between persistence in product innovation and technological leadership.

### 2.1. Persistence in innovation inputs

Empirical studies on persistence in innovation inputs have identified several determinants of persistence. These determinants are somehow related to the presence of cumulativeness in the innovative activity. First, cumulativeness may result from the presence of learning effects associated to innovative activity (Atkinson and Stiglitz, 1969). As the innovative activity of firms normally occurs along established technological trajectories (Dosi, 1982), it tends to be cumulative, irreversible, and localized (Dosi, 1988; Antonelli, 1998). According to this view, prior R&D investments to solve specific technological problems should lead to further explorations along the same trajectory and to further innovations. Second, cumulativeness may exist at the firm level because of 'success-breeds-success' phenomena. Successful innovations lead to further innovation either because they broaden the horizon of technological opportunities (Mansfield, 1968) or because they provide extra-profits that could be reinvested (Nelson and Winter, 1982). Peters (2009) studies persistence in innovation inputs in a panel of German firms between 1994 and 2002. She finds that persistence in inputs is particularly relevant for R&D performing innovators in manufacturing than for non R&D performing. Finally cumulativeness may result from the organization of the investment activity. If there are high sunk costs associated to innovation, barriers to entry and exit from R&D activities rise (Sutton, 1991) thus leading to persistence in innovation. Máñez et al. (2015) have studied persistence in R&D engagement by a sample of Spanish manufacturing firms over the 1990–2011 time period. Among other things, their findings highlight that Small and Medium-sized Enterprises operating in high tech industries have relatively higher persistence in R&D activities. They attribute this result to the presence of larger sunk costs in these industries.

### 2.2. Persistence in innovative (intermediate) outputs

Empirical studies of persistence in innovative (intermediate) outputs (i.e. patents) constituted the bulk of early studies in innovation persistence before the availability of subsequent cross sections of survey data (i.e. the Community Innovation Surveys) allowed to focus upon other types of output such as product or process innovations. These patent based studies have produced a series of 'stylized facts' on innovation persistence. First, production of intermediate outputs is subject to little dynamic economies of scale as the effect of prior innovations becomes apparent only after a 'minimum innovation threshold' is reached (Geroski et al., 1997). The threshold level of patents likely to induce a patenting spell of 3 or more years is around 5 patents. A firm that produces 5 or more patents has roughly two times the probability of enjoying a patenting spell of any length greater than 3 years than a firm that produces only 4 patents. Second, there is bimodality in the pattern of innovation persistence (Cefis and Orsenigo, 2001). In particular, persistence is stronger for firms that are either non innovators or great innovators (i.e. having 6 or more patents in a year). This means that most firms innovate only occasionally or do not innovate at all. Yet innovative activities are to a significant extent generated by few firms

[1] For a more comprehensive review see also: Le Bas and Scellato (2014) and their introduction to the special issue of *Economics of Innovation and New Technology* on: "Innovation persistence new research perspectives".

Please cite this article in press as: Fontana, R., Vezzulli, A., Technological leadership and persistence in product innovation in the Local Area Network industry 1990–1999. Res. Policy (2016), http://dx.doi.org/10.1016/j.respol.2016.04.002