Research Policy 42 (2013) 340–352

Contents lists available at SciVerse ScienceDirect

Research Policy

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

Understanding innovation: An analysis of persistence for Spanish manufacturing firms

Ángela Triguero*, David Córcoles

Facultad de CC. Económicas y Empresariales, Universidad de Castilla-La Mancha, Plaza de la Universidad 1, 02071 Albacete, Spain

ARTICLE INFO

Article history:
Received 16 February 2011
Received in revised form 24 July 2012
Accepted 10 August 2012
Available online 7 September 2012

JEL classification:
O31
D22
C23

Keywords:
R&D
Innovation
Persistence
Panel data
Firm heterogeneity
Market characteristics

ABSTRACT

This study focuses on the persistence of innovation in a panel of Spanish manufacturing firms for the period 1990–2008. In particular, we analyse whether persistence in firms' innovation activities over time is the result of previous experience, the dynamic capabilities of the firm or industry-market related characteristics. We find that R&D (input) and innovation (output) are highly persistent at the firm level. After controlling for unobserved heterogeneity and initial conditions and by using a dynamic random effects probit, we conclude that there are similar determinants of persistence in R&D and innovative activities. Among external/environmental factors, market dynamism affects R&D and innovation. Regarding firm specific characteristics, size and outsourcing also have a positive impact on both processes. Past innovative behaviour is clearly more decisive in explaining the current state of R&D and innovation activities than external factors or firm-level heterogeneity.

1. Introduction

In recent years, analyses of the relationship between innovation and industrial dynamics have generated a wide array of theoretical and empirical contributions. Progress in new econometric packages and the availability of large panel data sets at the firm level have allowed researchers to identify some stylised facts and empirical regularities related to the high within-industry heterogeneity in innovation (Malerba, 2007). This heterogeneity is due, among other things, to differences in the ability to innovate. As Dosi (1997) notes, heterogeneity in innovation across firms indicates the presence of particular capabilities and implies that even when firms perform the same activities, they can do so in different ways. In this sense, substantial research efforts have been devoted to examining persistence in innovation (Cefis, 2003; Malerba et al., 1997; Peters, 2009; Raymond et al., 2010), showing that 'innovation is not a purely random phenomenon driven by small shocks, but it implies systematic heterogeneity across firms. . .' (Cefis and Orsenigo, 2001, p. 1156).

Additionally, several studies empirically address the propensity of firms to innovate. Innovative activity has been proxied by input (R&D effort) and output measures (patents or the number of innovations). This paper provides the first dynamic approach to innovation persistence, focusing on both perspectives.[1] We estimate that there will be a strong (and positive) relationship between input (R&D) and output (final innovation), but R&D spending does not necessarily ensure that innovation occurs. Engaging and persisting in R&D primarily depends on firm-level decisions, but the results (final innovations) are affected by other external factors such as market dynamism and the competitive environment.

This paper examines the dynamics of innovation and R&D decisions in Spanish manufacturing using firm-level data for the period 1990–2008. Its first aim is to analyse persistence in R&D and innovation to clarify the role played by past behaviour in the innovation process. Second, we attempt to determine whether there are differences in the effects of the explanatory variables on the probabilities of being an innovator and engaging in R&D activities. Thus, the goal is to discover the factors that are effectively driving the observed differences in these probabilities. More particularly, we attempt to

* Corresponding author. Tel.: +34 967 59 92 00x2342; fax: +34 967 59 92 00.
E-mail addresses: Angela.Triguero@uclm.es (Á. Triguero), Corcoles@uclm.es (D. Córcoles).

[1] As Kemp et al. (2003) note, there are no separate equations that explain the innovation process in most innovation process studies.

0048-7333/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.respol.2012.08.003

answer two related sets of questions. First, are R&D and innovation persistent at the firm level? Do significant differences exist between the persistence of R&D and the persistence of innovation? Second, what is the relationship between R&D and innovation? Are the factors that influence these decisions similar? What is more relevant in the innovation process, state dependence or firms' unobserved heterogeneity?

This paper contributes to the literature in several ways. First, we study persistence in innovation over time using R&D (input) and innovation (output) panel data on Spanish manufacturing firms. To the best of our knowledge, there are no other studies that directly consider both types of measures to study persistence in innovation. To do so, we use a dynamic random effects probit model proposed by Wooldridge (2005) that accounts for the initial conditions of the dependent variables. We also estimate Transition Probability Matrices and Survival Functions in innovation and R&D to detect whether persistent innovators coexist with persistent R&D performers. Finally, we broaden the current literature by including new variables in specifications based on the evolutionary theory of persistence in innovation (Le Bas and Latham, 2005).

The paper is organised as follows. First, we review the relevant literature on the dynamics and persistence of innovation and introduce a conceptual framework based on the evolutionary approach for analysing the relationship between R&D and innovation. Second, we describe the data and estimate transition probabilities to investigate R&D and innovation persistence. Third, to analyse the determinants of and persistence in R&D and final innovations, we estimate a random-effects dynamic probit and an alternative specification based on the Wooldridge correction. The main results of the model are presented in Section 4. Finally, we discuss the results of the research and draw some conclusions.

2. Theoretical and empirical background

The general theoretical literature presents three conceptually distinct reasons to expect that innovation-related activities are persistent. The first is based on the "success–breeds–success" assumption (Flaig and Stadler, 1994; Geroski et al., 1997). Actual innovative success positively affects further innovations in subsequent years. Although firms' innovation probabilities depend on the market structure, demand and cost expectations and unobserved heterogeneity, the positive, significant influence of past innovations shows a strong state dependence in the innovation process. Past innovations directly influence the firm's choice probabilities regarding innovation, confirming the structural state dependence of the choice.

Another explanation also focuses on how firms accumulate technological capabilities to improve their innovation outcomes. Knowledge accumulation ensures that today's knowledge and innovative activities support tomorrow's innovations (Breschi et al., 2000). Evolutionary theory suggests that the learning by doing effect enhances knowledge stocks and, therefore, the probability of future innovations (Peters, 2009). Firms learn by innovating and developing particular organisational competencies depending on their technological trajectories (Malerba and Orsenigo, 1999). Thus, the accumulation of technological capabilities could also explain how "failure breeds success" in innovation activities. A firm's heterogeneity in the knowledge accumulation process explains why firms have different degrees of persistence in the innovation process.

Finally, the properties of the knowledge base ensure that firms attempt to be "continuous" in their innovative activities. It is generally accepted that R&D involves, at least partly, sunk costs (Cohen and Klepper, 1996). R&D implies costs related to collecting information on new technologies, learning costs in technological adaptation, organisational changes and engaging in contracting or training a qualified workforce. These costs would be irrecoverable if the firm did not obtain any innovations. As the accumulation of new knowledge is not continuous, and the innovation process is characterised by uncertainty and complexity, firms should persistently invest in R&D to increase the probability of recovering their investments. As R&D spending does not guarantee innovation, we expect persistent R&D performers to have a higher probability of innovating than discontinuous R&D performers. In the same way, it is also advisable to innovate constantly because persistence in productivity or profits is explained by persistence in innovation (Cefis and Ciccarelli, 2005). Because many firms face financial obstacles that hamper their innovation projects when they have to seek external funding sources, they will only obtain financial resources when their past innovations ensured a permanent or continuous profit threshold.

Innovative persistence is an important topic in applied industrial organisation. A growing number of studies using patent data (Cefis and Orsenigo, 2001; Cefis, 2003; Malerba and Orsenigo, 1999; Le Bas et al., 2003) and innovation data (Geroski et al., 1997; Raymond et al., 2010) reveal that few firms innovate persistently. Conversely, persistence in innovation has been found to be high when measured by dynamic probit specifications using several panel data sets. Specifically, Duguet and Monjon (2002) examine the persistence of innovation in French manufacturing firms over the period 1986–1996. Roger (2004) also reports persistence effects using a survey of Australian firms conducted from 1994 to 1996; Roper and Hewitt-Dundas (2008) employ panel-data and case-study approaches for Irish firms over the period 1991–2002. Máñez et al. (2009) ascertain firm persistence in R&D activities using firm-level data for Spanish manufacturing in the period 1990–2000. Finally, Peters (2009) shows persistent innovation behaviour at the firm level using data on German manufacturing and service firms for the period 1994–2002.[2]

Most of these studies highlight the important role of individual unobserved heterogeneity at the firm level in explaining the persistence of innovation. There are several explanations for innovation persistence but there is not a general, comprehensive theoretical framework. Our theoretical framework stems from the evolutionary approach proposed by Le Bas and Latham (2005). In keeping with our research aims, we are interested in creativity, which refers to a firm's ability to enhance and improve products and processes (to innovate).[3]

In this paper, we analyse the implications of an evolutionary view of firm innovation persistence. Investments in knowledge activities (R&D) explain technological performance (Innov). Additionally, contemporary innovations are an incentive to initiate new R&D projects. For firm i, $Innov_{it} = 1$ if the firm has achieved product or process innovations in time period t, and $R\&D_{it} = 1$ if the firm has conducted or contracted for R&D activities during period t. With respect to empirical evidence, it is possible to account for bidirectional causation processes as is performed in the panel *VAR* approach purposed by Coad and Rao (2010). To consider these

[2] In this sense, Raymond et al. (2010) is the only study that found no evidence of true persistence in innovation output by estimating a dynamic model where persistence is measured through lagged innovation. They present evidence of true persistence in input innovation, but they find spurious persistence when considering the output side. We must note that this divergent result is obtained with panel data constructed using only three waves of the Community Innovation Surveys (CIS) (periods 1994–1996, 1996–1998 and 1998–2000).

[3] The other two dimensions of performance correspond to efficiency and fitness. Efficiency is the ability of the firm to transform innovation into economic success (profit). Fitness is the firm's ability and willingness to transform profits into new capital and growth. Although the three dimensions of performance are related, in this paper we are only interested in the capacity to convert R&D expenditures into innovation.