European Forum for Studies of Policies for Research and Innovation

2013 EU-SPRI FORUM CONFERENCE
MANAGEMENT OF INNOVATION POLICIES

Proceedings of the 2013 EU-SPRI Forum Conference
Madrid 10-12 April 2013
ISBN 978-84-695-7408-9 ORAL PRESENTATION

Title

Technological innovation and the challenges of novelty and failure: Evidence from Spanish manufacturing firms

Authors

Nabil Amara, Faculty of Business, Laval University, Pavillon Palasis-Prince Bur 1657, Quebec G1K 7P4, QC, Canada.

Julia Olmos Peñuela, INGENIO, CSIC-UPV, Universitat Politècnica de València, Edif. 8E, Camino de Vera s/n 46022 Valencia, Spain.
E-mail: juolpe@ingenio.upv.es

Pablo D'Este, INGENIO, CSIC-UPV, Universitat Politècnica de València, Edif. 8E, Camino de Vera s/n 46022 Valencia, Spain.
E-mail: pdeste@ingenio.upv.es

Keywords

Technological innovation, failures, novelty, determinants, manufacturing firms.

Objectives:

Technological innovations are important because they improve competitive advantages and create opportunities for firms to access new market (McDermott & O'Connor, 2002; Stock et al., 2003; Galia & Legros, 2004). However, technological innovations, especially radical technological innovations, involve higher risks and raise significant management challenges which enhance their probability of failure. Many prior studies showed that the percentage of innovation projects that failed either completely or partly is remarkably high and could exceed, in some cases, 70% of the initiated innovation projects. (e.g., Balachandra & Friar, 1997; Cozijnsen et al., 2000; Wycoff, 2003; Rizova, 2006).

The review of prior studies on innovation failures suggests that major methodological, theoretical and empirical difficulties should be taken into account in order to advance knowledge: the symmetries and asymmetries between success and failure, the conceptualization and the measurement of innovation failures, and the scarcity of empirical studies that aim to identify the predictors of learning from innovation failures.

Symmetries and asymmetries between success and failure: Many innovation studies comparing successes and failures rest on research designs where the first step is to identify critical factors likely to explain success. Then, in a second step, failure is explained by the lack of strength or the absence of one or many of these critical factors (Cozijnsen, et al., 2000; Connell et al., 2001; Cooper & Kleinschmidt, 2007). However, several researchers have underlined differences separating successes from failures in innovation projects (Hoetker & Agarwal, 2007; Madsen & Desai, 2010). They pointed-out that it would be more difficult to stop unsuccessful ongoing innovation projects than to start new ones (Balachandra et al., 1996). Starting new innovation projects often motivates the personnel, while stopping ongoing projects risks demotivating staff and it increases uncertainty about their future careers (Staw & Ross, 1987; Jani, 2011). Moreover, innovation projects create entrapment situations where managers need to continue supporting projects in order to justify previous investments in them (Brockner et al., 1986; Schmidt & Calantone, 1998).These significant asymmetries between success and failure suggest that factors predicting failure might differ from those predicting success.

Conceptualization and measurement of innovation failures: Most studies on innovation failures are conceptual or based on case studies that are rich in insights but not easy to generalize (see Pandya & Dholakia, 2005; Anthony et al., 2006, for illustration). Another problem is related to the fact that this concept usually refers to a new product development project that is killed before completion. However, there are many stages in a project's life cycle where managers can decide to terminate a project (Balachandra, 1984; Stevens & Burley, 1997): 1) before any resources are invested (idea failure), 2) during its development stage (technological failure), or 3) after the market introduction of a product (commercial failure). This study will contribute to advance knowledge by focusing directly on innovation failures and by distinguishing between the two types of innovation failures, namely idea failure, and technological failure.

Identification of predictors of innovation failures: The scarcity of studies that consider innovation failures as dependent variables ensures that there is no consensus regarding the predictors of innovation failures. However, to identify such predictors, many experts argued that innovation is a cumulative process (Scotchmer, 2004;

Magazzini et al., 2012), i.e. failures cannot be isolated from other phenomena related to the innovation process (Garcia-Vega & Lopez, 2010). For instance, in the existing empirical literature, the decision of a firm to innovate, its decision regarding the degree of novelty of its innovations, and about terminating or not an innovation project are generally studied separately. In practice, for example, the decision of a firm to develop innovation with a high degree of novelty may force it to evolve beyond its existing technological capabilities (Danneels & Kleinschmidt, 2001; Townsend, 2010). The higher the discontinuity between technological, human, and knowledge resources required for the development of an innovation and the existing bundle of resources that a firm has, the more likely an innovation project is to be abandoned (Yap and Souder, 1994; Green et al., 1995; Garcia & Calantone, 2002). In this paper, we will advance knowledge by addressing the issue of how innovation, degree of novelty of innovation, and innovation failures are connected together, i.e. to what extent these three variables go "hand-in-hand".

More specifically, this paper addresses the following questions: 1) To what extent technological innovation, novelty of innovation, and innovation failures go "hand-in-hand"? 2) What are the factors that lead innovation projects to termination? 3) Are there differences in the factors explaining the innovation projects that succeed and those that are terminated by managers? Implications will be derived to help managers to enhance the probability of their innovation projects' success, and policy makers to develop public policies supporting innovation in manufacturing industries.

Methodology:

The data analyzed for the present study come from the Spanish Technological Innovation Panel (PITEC) conducted in 2009. The survey was realized by the Spanish National Statistics Institute (INE), and sponsored by the Science and Technology Foundation (FECYT) and the Foundation for Technical Innovation (COTEC). A total of 11,775 manufacturing and service firms responded to the survey. For the purpose of this paper, we focused on manufacturing firms which restricted our analysis to 5,387 observations.

A Multivariate Probit Model was estimated (MPM). It consists in our study of six binary choice equations. These choices are for three classes of dependent variables: technological innovation variables (*product innovation* and *process innovation*); degree of novelty of innovation variables (*innovation that is new to the firm* and *innovation that is new to the market*); and innovation failure variables (*abandonment in conception phase* and *abandonment once the project was started*). The explanatory variables are regrouped in the following seven categories: 1) External knowledge sources; 2) Knowledge creation; 3) Complementary knowledge asset; 4) Management strategies; 5) Barriers to innovation; 6) Industry sectors; and 7) Control variables.

Results:

The results of this study show that all the estimates of the correlation of the error terms of the six equations are significant at the $p = 0.05$ level, except the correlation between process innovation and abandonment once the project is started. These results suggest that the dependent variables referring to product innovation, new to the

firm, new to the market, abandonment in the conception phase, and abandonment once the project is started, go "hand-in-hand". Likewise, the correlation coefficients of the error terms of the variables process innovation, new to the firm, and abandonment in the conception phase, are positive. Positive correlation was also found between new to the firm, abandonment in the conception phase, and abandonment once the project is started. However, the results indicate significant and negative correlations between product innovation and process innovation, between process innovation and new to the market, and between new to the firm and new to the market. These results also suggest some pattern of specialization among the innovative firms of our study.

The results also show that firms which are innovative in product are more likely to abandon innovation projects in the conception phase, and once the projects are started, whereas firms that are innovative in process are more likely to terminate their innovation projects in the conception phase. Moreover, and as expected, the degree of novelty of innovation (*innovation that is new to the firm* and *innovation that is new to the market*) goes hand-in-hand with innovation failure variables (*abandonment in the conception phase* and *abandonment once the project is started*).

Results also indicate that knowledge contributes to the decrease of likelihood of failure of innovation projects, as shown by the negative impact of internal R&D, and research sources index on the likelihood of failure of innovation projects. By comparing factors explaining the innovation projects that succeed and those that are terminated, results indicate that firms which are more concern with corporate social responsibility (CSR) are more likely to conduct riskier projects (*innovation that is new to the market*) and less likely to face failures in innovation project already started.

Finally, another interesting result is the differences found in the likelihood of project innovation novelty and failures according to the type of external knowledge sources used. Market sources increase the likelihood of novelty innovation (*innovation that is new to the firm* and *innovation that is new to the market*) and also the abandonment of the innovation project in the conception phase. However, research sources increase the likelihood of novelty innovation (*innovation that is new to the market*) but decreases the likelihood of project innovation failures (*abandonment in the conception phase* and *abandonment once the project is started*).

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