

**BATTLE ROYAL IN BIOTECHNOLOGY:  
R&D VS PRODUCT VS PROCESS INNOVATIONS**

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**Abstract**

Companies regard innovation as a central element of their business. However, as not all innovation types are the same, the central question is: should their announcements bring about the same effect on performance? This article analyses potential differences in firm value derived from the innovation-type announcements ‘R&D’, ‘product’ and ‘process’, made by intensive news-generating firms such as biotech companies. The empirical application shows a significantly positive reaction to innovation announcements, with the prospect of future innovation (‘R&D’ investment announcements) having greater impact on firm value than ‘product’ and ‘process’ innovations. Firm experience also acts as a moderator in this innovation-performance relationship, which is particularly relevant for entrepreneurs, who need to develop and send credible signals indicating the value of the firm's intangible assets to the market.

**Key words:** biotechnology; innovation; R&D; firm age; firm value.

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## **1. INTRODUCTION**

Innovation is a crucial element in today's firm development, productivity and competitiveness (Máñez et al., 2005; Fetterhoff and Voelkel, 2006; Wolff, 2006; Hahn, 2010; Delgado-Verde et al., 2011; Damijan et al., 2012; Martinez-Senra et al., 2013); still, it is not unusual to find innovating firms that often fail to obtain economic returns from their innovative activities (Su et al., 2013). In this article, we focus on biotechnology firms, for which innovation is a particularly critical cornerstone (Casper et al., 1999; Cooke, 2001; Gertler and Levitte, 2005; Tripl and Tödtling, 2007), by analysing three types of innovation announcements (R&D, process and product innovation).

According to the United Nations, biotechnology consists of 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use'. Consequently, ongoing innovation is, per se, a central, core element for biotechnology and for the firms involved in this industry (McMillan et al., 2000). Therefore, innovation defined as something original, new, and important that breaks in to a market or society (Frankelius, 2009) has special relevance in this industry.

In general terms, the positive relationship between innovation and performance has been widely shown (Naranjo-Gil, 2009; Bayona-Sáez and García-Marco, 2010; Yam et al., 2011; Trigo and Vence, 2012), due to the higher probability of survival (Hall and Williams, 2008), higher competitive edge gained (Victorino et al., 2005), the differentiation reached (Walsh et al., 2008) and cost reductions attained (Chan et al., 1998). This positive relationship between innovation and performance has been found by using different indicators of firms' innovation capabilities, such as R&D (Toivanen

et al., 2002; Eberhart et al., 2004; Hall and Oriani, 2006) or new products (Angelmar, 1990; Chaney and Devinney, 1992; Geroski et al., 1993; Srinivasan et al., 2009).

However, not all innovations are equal or have the same implications (Amable and Palombarini, 1998; Tether, 2001; Zach and Fesenmaier, 2009), which is why Hjalager (2010) claims that more research is needed to evaluate the potential differentiated effect of *innovation types* on performance. That's why this article attempts to analyse potential differences in the innovation-type announcements made in terms of R&D, product and process. While discussed more in detail later, in general terms, *research & development* must increase the firm's sales (Natsukawa et al., 2013; Ma et al., 2014), *product innovation* implies an improvement in a product which is expected to generate greater turnover (Guo et al., 2013; Høyvarde and Pohjola, 2013; Su et al., 2013), and *process innovation* involves an improved production method leading to efficiency enhancement (Barge-Gil et al., 2011).

Moreover, the literature shows that the firm's experience exerts a significant impact. Sahra (1996) indicates that new ventures -eight years or younger-, 'play a major role in the development of an emerging, high-technology industry'. Accordingly, along with this non-linear effect, and considering that entrepreneurs need to develop and send credible signals indicating the value of a recently created idea, we examine whether experience moderates the effect of innovation types, in such a way that managers can detect the best decisions in terms of innovation depending on the age of the firm.

With the objective of analyzing potential differences in firm value derived from the innovation-type announcements 'R&D', 'product' and 'process', made by biotech companies, we first detect all the innovations announced by any biotechnological company ever trading in the Spanish market between 1994 and 2008 (the Factiva database is used for this purpose), leading to 26 innovation announcements. The

subsequent sections of the article are arranged as follows: Section 2 reviews these types of innovation and proposes several explanatory variables of firm value; Section 3 outlines the method and data employed; Section 4 describes the results; and Section 5 presents the conclusions.

**Insert Figure 1 about here**

## **2. INNOVATION IN BIOTECHNOLOGICAL COMPANIES**

On July 28, 2011, The Washington Post published the ‘top 10 most innovative biotech companies’. While in other industries other criteria are used, for biotechnology-related firms, their innovation capability is employed to establish a definite ranking. Certainly, innovation is an essential decision area for them, and as such, they try to keep the public aware of their innovative actions. But, how do they let the market know of their progress in this field? The communication strategy, which is critical these days (Rose et al., 2007), revolves around R&D announcements, product and process innovations (see Figure 1).

Regarding *research & development*, this term is defined by the OECD (1993) as ‘research and experimental development comprised of creative work undertaken on a systematic basis in order to increase the stock of knowledge, (...) and the use of this stock of knowledge to devise new applications’. Accordingly, it may or may not lead to a practical application, but in the end, the aim of R&D should be focused on the creation of innovations for commercial exploitation; therefore, R&D should eventually lead to an increase in sales.

Product innovation is the ‘introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. Product

innovations can utilize new knowledge or technologies, or can be based on new uses or combinations of existing knowledge or technologies' (Oslo Manual, 2005). Note that the notion of 'product' implies a complex process influenced by technology development, shifts in customer needs and wants, length of product life cycles and degree of global competition (Gunday et al., 2011), leading to different innovation persistence across types of product innovation (Høyvarde and Pohjola, 2013). As Akova et al. (1998) indicates, it implicitly leads to the observation of a strong interaction with all the decision areas within the firm and the firm with its customers and suppliers.

Process innovation is the 'implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. Process innovations can be intended to decrease unit costs of production or delivery, to increase quality, or to produce or deliver new or significantly improved products' (Oslo Manual, 2005). Note that, according to Gunday et al. (2011), process innovations are linked to technological developments. All these three types of innovations come with a cost that is expected to be subsequently paid-off. In fact, note that the emphasis of process innovation is made on its cost-cutting nature (Fagerberg et al., 2004); that is, a basic objective of process innovation is to reduce costs irrespectively of the expected demand.

Therefore, the following hypotheses are proposed:

**H.1a.:** *R&D leads to an increase in firm value.*

**H.1b.:** *Product innovation leads to an increase in firm value.*

**H.1c.:** *Process innovation lead to an increase in firm value.*

At this point, the key question is which innovation type is expected to have a greater impact on firm value (see Figure 1). No universal statement can be established, since there are differences both between and within innovation types. A priori, no

ranking among them can be set as it all depends on the amount of costs and sales expected. So far, abstract affirmations have been stated such as ‘process innovations are more influential than product innovations’ (Hjalager, 2002; Weidenfeld et al. 2010), but, still, it is not straightforward to make general assertions on this issue. At most, one could argue that R&D is more expectation-dependent, as they are future promises of tangible items; and product and process innovations, on the contrary, are real materializations of past R&D investments. On this account, this different approach might lead to distinct perceptions of the effect on performance. Consequently, we propose the following hypotheses:

**H.2a.:** *R&D (as a promise of future tangible items) has an effect on firm value which is different from product innovations (which is already tangible).*

**H.2b.:** *R&D (as a promise of future tangible items) has an effect on firm value which is different from process innovations (which is already tangible).*

It is important to consider the firm experience (firm age) as a moderator of the three types of announcements. The effect of firm experience on innovation has only been approached recently, despite its paramount importance for entrepreneurs that need to develop and send credible signals indicating the value of the firm's intangible assets to the market (Deeds et al., 1997). Sorensen and Stuart (2000) and Huergo and Jaumandreu (2004) conclude, in general terms, that as firms accumulate experience, their innovation quality changes. It has only been as recently as 2008 that Balasubramanian and Lee (2008) confronted the two mainstream opposing theories posited to explain the age-innovation relationship. On the one hand, learning-by-doing can be applied to innovation, so that the firm’s innovative abilities might be enhanced as it increasingly acquires more experience; and on the other hand, organizational inertia

can take over: the organizational capabilities learned over the years certainly bring about positive returns, but they are not easy to create and, more importantly, they might imply high costs. Therefore, if the firm has incurred such costly investment, it will have quite a low willingness to get involved in major adjustments to its already-created-and-costly-adjusted capabilities. In their study, Balasubramanian and Lee (2008) find that ‘each additional year reduces the impact of a 10% increase in R&D intensity on the firm's market value by over 3%’: as the firms accumulate experience, their net adjustment costs rise. In the face of this evidence, the signal created by an innovation announcement should be more positively impacting on younger firms, as riskier and more daring -and consequently, more profitable- innovative actions that could imply further re-adjustments to the firm’s capabilities are more likely to occur among younger firms. Therefore, we propose in hypothesis 3 that:

**H.3.:** Firm’s experience exerts a moderator effect on the impact of innovation on firm value.

Finally, we add two control variables to the proposed relationships in Figure 1 (intangible character and growth): i) *Intangible character*: Most of the literature on innovation has focused on manufacturing, but there are differential characteristics on the part of services that are necessary to be considered in innovation research (Camacho and Rodriguez, 2008; Criscuolo et al., 2012; Zach, 2012; Tussyadiah, 2013). In fact, Tether (2005) empirically finds, in his analysis of 3,014 European firms found in the Innobarometer Dataset, that service companies have a different innovation orientation from manufacturers. In particular, while manufacturers carry out innovation changes in a more occasional discrete step-wise way, service companies are more used to undertaking continuous changes, which are mainly oriented to improving ‘soft’ capabilities (e.g. skills of their workforce or co-operation practices with suppliers and

customers) (Tether, 2005). Consequently, on the one hand, ‘changing continuously’ leads service companies to consider adaptation and adjustment as the norm; and on the other hand, as they are more inclined to organizational innovations (more than to the development of new products and new processes) (Tether, 2005), the concomitant changes derived from these innovations should be less costly, both in monetary terms and in re-adjustments efforts. And ii) *Growth*: The relationship between innovation and growth is a two-way street: innovation is essential for growth (Bishop et al., 2009), and growth is critical for innovation (Mansury and Love, 2008; Mason et al., 2009). A priori, the higher the firm’s growth, the greater the impact of an innovation announcement on firm value. Given that the company has grown, it is expected that its capacity to keep on innovating will continue in the future (Mason et al., 2009), enhancing its future perspectives. This argument is in line with the discussion of Blundell et al. (1999) about the relationship between innovation and market share. They find that the effect of innovation on market value is higher for companies with a higher market share, suggesting that leading firms tend to bring about innovations that are intrinsically of higher quality. Freel (2000) points out that ‘although it is not necessarily true that *innovators are more likely to grow*, nevertheless *innovators are likely to grow more*’.

### **3. METHOD AND DATA**

The method followed to test the stated variables is as follows: to test the effect of innovation announcement on the market value (H1), we rely on the event study methodology; and for innovation types (H2) and the moderator effect of experience (H3) (along with the control variables), we employ regression analysis.

*Event study.* The use of the event-study method allows us to measure the potential existence of abnormal returns derived from the stock market reaction to

innovation announcements. In this context, Park and Kim (1997) indicate that the firm's stock price reflects the market judgment of the likely payoffs from entrepreneurial activities, so it might show a distinction depending upon the firm's experience. According to McWilliams and Siegel (1997), we first detect all the innovations announced by any biotechnological company ever trading in the Spanish market between 1994 and 2008 (the Factiva database is used for this purpose). The event day is defined as the first day in which the news is released. The search detects 31 innovation items belonging to the six biotechnological firms that trade in the Spanish Stock Exchange with an average number of five innovations each. Note that the focus is on the announcement, which turns out to be the relevant data for the analysis. Next, we look for possible confounding news published close to the announcement day, such as takeover bids, profit announcements, dividend declarations, split announcements, complaints, claims, government contracts, court cases, or labor disputes, etc. Accordingly, 5 announcements appear to have confounding effects, so we are left with 26 news items. Finally, we collect data on market measures of performance: daily returns on the shares of the 26 innovation announcements during the period January 3, 1994 to 31 December 30, 2008, a temporal period defined by the availability of daily stock market information. These daily returns are adjusted with dividends, subscription rights and splits. The returns on the share price of a company  $i$  on day  $t$  ( $R_{it}$ ) are expressed as:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad (1)$$

where  $R_{mt}$ =returns on the market portfolio on day  $t$  (this study uses the IBEX-35, a representative index of the Spanish Stock Market; the information is obtained from the Stock Exchange Society);  $\alpha_i$ =returns on the shares of company  $i$  independent of those of the market;  $\beta_i$ = sensitivity of returns on the share  $i$  to variations in market returns; and

$\varepsilon_{it}$  = error term. The estimation of equation (1) allows us to calculate daily abnormal returns (AR) for a company  $i$  announcement:

$$AR_{it}=R_{it}-(a_i+b_iR_{mt}) \quad (2)$$

where  $a_i$  and  $b_i$  are the estimations of the regressions (1) for a period  $T$  before the event. It is important to note that the characteristic kurtosis and heteroskedasticity in the error term of equation (1), which have been detected in various empirical applications, would lead to defective estimates. For this reason, this study estimates an autoregressive conditional heteroskedasticity model, GARCH(1,1), whose main purpose is to model the conditional variance of the returns. Such models distinguish between unconditional variance, which is constant and stationary, and conditional variance, which is modified by the available information. Thus, the returns defined by means of this specification are obtained by assuming that

$$\varepsilon_{it}= h_{it}^{1/2}\eta_{it} \text{ and } \varepsilon_{it}/\varepsilon_{it-1}, \varepsilon_{it-2}, \dots \sim N(0, h_{it})$$

where  $\eta_{it}$  i.i.d. with  $E(\eta_{it})=0$  and  $E(\eta_{it}^2)=1$ .

In this context,  $h_{it}$  is the conditional variance and is represented as

$$h_{it}=c_i+\lambda_i\varepsilon_{it-1}^2+\gamma_i h_{it-1} \quad (3)$$

where  $c_i$ ,  $\lambda_i$  and  $\gamma_i$  are parameters to be estimated.

To confirm the results, we also estimate abnormal returns through the Theil nonparametric regression technique is used, according to the following process: i) sort the  $T$  pairs of  $(R_t, R_{mt})$  in the estimation period in ascending order of the  $R_{mt}$ ; ii) separate the data pairs into two groups based on the median, excluding the median pair if  $T$  is odd; iii) calculate a slope parameter  $\beta$  for each of the  $T/2$  data pairs in each group by computing the expression

$$\beta_{t,t+\frac{T}{2}} = \frac{R_{t+\frac{T}{2}} - R_t}{R_{m,t+\frac{T}{2}} - R_{mt}} \quad (4)$$

iv) Sort the calculated slope parameters in ascending order; v) estimate  $\beta$  with the median slope and compute the values of  $\hat{\alpha}_t$  for all data pairs; and vi) estimate  $\alpha$  with the median value of the  $\hat{\alpha}_t$ .

To analyse the effect of a biotechnological company's innovation announcement on its share price, this article tests the significance of its average abnormal returns in the event window (-1,+1) using the traditional test of Brown and Warner (1980).

*Regression analysis.* To test the variables we rely on regression analysis, so that 'innovation types' ( $PDI_i$ =product innovation and  $PCI_i$ =process innovation), 'experience' ( $Exp_i$ ), 'growth' ( $Gr_i$ ) and 'intangible character' ( $Int_i$ ) are included as explanatory variables of 'excess returns' or 'abnormal returns' ( $AR_i$ ). Subscript  $i$  refers to the information of the company at the time of the innovation announcement  $i$ . The resulting regression is as follows

$$AR_i = \delta_1 + \delta_2 PDI_i + \delta_3 PCI_i + \delta_4 PDI_i Exp_i + \delta_5 PCI_i Exp_i + \delta_6 Exp_i + \delta_7 Gr_i + \delta_8 Int_i + \mu_i \quad (5)$$

where  $\mu_i$  is the error term. Note that to test the hypothesised moderating effect of experience, the variable  $Exp_i$  must also be included alone, together with the interaction term (Baron and Kenny, 1986). It means that experience not only can have a moderating effect on the relationship 'abnormal returns–innovation type', but also a direct effect on abnormal returns. Therefore, according to the terminology of Sharma et al. (1981), the variable 'experience' can behave as a 'pure moderator' (i.e., if it has only a moderating effect through its interaction with 'innovation type') or as 'quasi-moderator' (i.e., if it has both a moderating effect through its interaction with 'innovation type' and a direct effect in itself).

As The measurement of these explanatory variables in the regression analysis is as follows: Innovation types (R&D, product and process innovations) are measured through dummy variables (R&D is taken as the base alternative). Firm experience is measured by age. According to Balasubramanian and Lee (2008), firm age captures overall firm experience, as it can incorporate all the effects of learning processes and accumulated knowledge that can have an impact on innovation. For ‘intangible character’, a categorical variable is used, which takes value 1 if the firm includes service components and 0 if it is a pure manufacturer. Growth is calculated through the average annualised growth in turnover over the last three years prior to the announcement, defined as  $Growth = 1/3 \cdot [\ln(\text{turnover}_{t-1} / \text{turnover}_{t-3})]$ . For a summary, see Table 1.

**Insert Table 1 about here**

#### **4. RESULTS**

Table 2 shows the estimation of the average abnormal returns of the 26 announcements in the (-1+1) event window. The results obtained demonstrate that, on average, innovation announcements are associated with positive excess returns on the previous day; in particular, both estimation procedures lead the Brown and Warner test to present significant values on day -1. This means that, on average, firms announcing innovation activities undergo a minimum gain of 0.54% on the day before the announcement. This one-day advanced reaction seems plausible as innovation announcements of biotech companies might leak before formal, public releases. This result supports hypothesis 1 that R&D, product innovation and process innovation lead to an increase in firm value, which is in line with the extant literature (Bayona-Sáez and García-Marco, 2010; Yam et al., 2011; Trigo and Vence, 2012).

**Insert Table 2 about here**

Once the abnormal returns are estimated and tested, we analyse whether the distinct innovation types have differentiated effects on these abnormal returns. Table 3 shows the results of the regressions conducted. We estimate two equations, one with the Garch-generated abnormal returns and the other with the Theil-generated excess returns.

As for the individual parameters, we find that the effect of ‘R&D’ is significantly greater than both ‘product’ and ‘process’ innovations’. These greater returns are confirmed in the two equations. Also, the chi-square test finds that there are no significant differences between ‘product’ and ‘process’ innovations in either equation ( $\chi^2=3.46$ ;  $p>0.05$  and  $\chi^2=2.15$ ;  $p>0.05$ ). These results suggest that the distinct character between ‘future promises of tangible items’ drive greater perceptions of performance than ‘already materialized product and process innovations’, supporting hypothesis 2 that R&D has a differentiated effect on firm value when compared to product and process innovations.

**Insert Table 3 about here**

As for the moderating effect of experience, we find that the innovation type effect is reversed as the firm gets older: for more experienced firms, the effects of ‘product’ and ‘process’ innovation tend to exceed that of ‘R&D’ (as before, no differences exist between ‘product’ and ‘innovation’ in either equation [ $\chi^2=1.40$ ;  $p>0.05$  and  $\chi^2=1.13$ ;  $p>0.05$ ]). This result is in line with hypothesis 3 that firm’s experience exerts a moderator effect on the impact of innovation on firm value. To be specific, according to Sharma et al.’s (1981) taxonomy, ‘experience’ appears to be a quasi-moderator (rather than a pure moderator), as the variable itself has an effect on firm value; in particular, it is significantly negative, supporting the theory that innovation has

a higher effect on the firm value of younger companies. This result is in line with the evidence found by Balasubramanian and Lee (2008), on account of the riskier but more profitable innovative actions of younger firms. Table 4 presents these main results regarding the hypotheses tested:

**Insert Table 4 about here**

Finally, regarding the ‘intangible character’, it is significant in both equations, while ‘growth’ is not. The intangible character has a negative sign, which means that, there might be differential characteristics on the part of services that are necessary to be considered in innovation research, as they have a different innovation orientation (Camacho and Rodriguez, 2008; Tether, 2005).

## **5. CONCLUSIONS**

Companies within the biotechnology industry regard innovation as a core activity. Therefore, implementing such activities is an essential decision area for them; furthermore, letting the market know about these activities is critical in terms of public relations strategies. The adequacy of right announcements helps them convey a specific image and, on this account, it is relevant to analyse potential differences in the innovation-type announcements. This is especially relevant for entrepreneurs, who need to develop and send credible signals indicating the value of the firm's intangible assets to the market, and this is even more relevant if we consider that new ventures and younger companies play a major role in the development of an emerging, high-technology industry. This study shows that younger firms send these credible signals appropriately and better than older ones.

The empirical application also finds a significant reaction when the innovation-related information is released, showing that the prospect of future innovation (‘R&D’ investment announcements) has greater impact on firm value than ‘product’ and

‘process’ innovations. As stated, this effect is moderated by ‘experience’ in such a way that as the firm gets older, the latter innovations tend to increase the firm’s value greater than the former (even though, the total impact is still outperformed by ‘R&D’).

Accordingly, implications for management revolve around the idea of properly communicating the right type of news. In the light of the results, expectations are a key element when it comes to firm value formation. Therefore, biotech companies must pay attention, not only to their new products and processes but also to their new ideas, contracts and all kind of potential activities that can lead to effective R&D activities.

The finding that the biotech market value varies when the prospect of innovation activities is announced indicates that this measure can be regarded as appropriate to analyse this type of investments. The use of market value facilitates the analysis of the effect of innovation on performance by estimating unbiased market predictions on future profits. This technique employs a forward-looking firm performance that overcomes all the difficulties of the traditionally used backward-looking firm profitability, i.e., accounting measures. Specifically, once the innovation is announced, managers might observe the evolution of share prices to determine how valuable the news is perceived to be by the shareholders. If the shareholders’ perceptions of it are not as good as the managers would have expected, they may want to see whether this is due to a lack of information (or even to misinformation). If this were the case, a new flow of information should be released, in order to clarify the firm’s innovation. Also, finding that innovation has a positive impact on firm market value means that the market considers that an innovative company is a healthy firm. Therefore, any biotech company introducing innovations, no matter whether they are internal or external, should show that it is innovating all the time, by releasing information through a well-executed public relations program. For example, in the event of getting an innovation award, it

would represent a way of demonstrating that the decisions made on innovative issues have been correct. This can reduce agency conflicts and reinforce the trust shareholders have in the management team. In a time when uncertainty is the norm, showing that one's decisions have been appropriate is not trivial. Ultimately, innovation can help the firm position itself in people's minds.

This fact, along with the outcome that these variations in biotech market value are contingent upon the type of innovation, suggests that, when a comprehensive examination is pursued, different types of innovations and distinct kinds of measurements should be employed. While innovation types are expected to lead to different results, the use of several performance measures (as firm value) might permit the identification of hidden effects that, otherwise, would not be easy to uncover. Note that, in the end, using distinct performance measures implies looking at the company from different perspectives; perspectives that represent facets that might be worth looking into them.

Finally, the youth of a firm that sends innovation-related information seems to be captured by the market and, therefore, it is relevant information for venture capitalists. Firm value reflects higher increases derived from innovation announcements in younger firms than older due to the riskier but more profitable innovative actions of younger firms. Mistakenly or not, the market seems to have the perception that older firms are less adventurous and more reluctant to change. Accordingly, such firms should pay special attention to this fact and provide the market with extra information as to the scope and reach of their innovations.

Regarding the study's limitations, two shortcomings have to be considered: i) The small sample size used. It is true that existing empirical applications of the event study technique show that it might still be large enough to detect reactions in share

prices (Gomez, 2001), and that, according to the data collection process followed, it is guaranteed that the sample contains all the news items released during the study period, but the reduced sample certainly prevents us from making generalizations; and ii) Ideally, the appropriate test to find differences in the effects of ‘future promises’ (R&D) and ‘materialized promises’ (product and process innovations) should consider the string of investments, from the outset to the final output, in a specific item; that way, one could observe the variations in firm value both, at the time of announcing prospective research on an issue and at the time of producing tangible results. However, this is not always possible as, first, no specific information is always provided when general statements about R&D investments are announced, and second, even if it were provided, it would not be easy to determine a correlation between each new created item and each euro spent in R&D activities that lead to several brand-new items.

For further research, several lines can be followed in order to provide a more comprehensive view of the relationship between innovation and biotech market value:

- 1) The paper has used the Schumpeterian classification to identify differentiated effects in innovation types; nevertheless, the use of other taxonomies would offer a broader view in terms of academic perspectives (as it would permit the identification of the best explanatory classification) as well as in terms of management perspectives (as it would show decision-makers the best innovation types according to the taxonomy used).
- 2) A larger sample would permit the use of more potential explanatory factors.
- 3) The use of specific information on each innovation, especially in terms of costs incurred in the investment could shed more light on the specificities of every initiative; that is, knowing the cost invested in an innovation could determine how costly (per unit) the variations in market value are.
- 4) As market value has been shown to reflect innovation announcements, it is possible to analyze the effect of innovation-based competitive

reactions on the firm. In other words, as the market value captures the firm's innovation strategy, it could be expected that it will reflect the competitor's innovation strategy too. It would facilitate a rivalry analysis between actions and reactions based on innovation strategies. 5) With the advent of new technologies, other measurements of innovation impact can be used. If "twitter" were treated as a market where information is exchanged, and the number of "tweets" were considered as a measure of repercussion (or hype), it could be interesting to observe the expectations generated by an innovation announcement on a specific day. Paralleling the method employed in this article, it would imply observing whether the amount of "exchanged information" (tweets) derived from a firm's release of news on a given day is abnormally superior to the quantity of "exchanged information" in a normal day, and *whether and how many good things* are published.

## REFERENCES

- Akova, B., Ulusoy, G., Payzın, E., Kaylan, A.R. (1998). New product development capabilities of the Turkish electronics industry. In: Proceedings of the Fifth International Product Development Management Conference, Como, Italy, pp. 863–876.
- Amable, B. and Palombarini, S. (1998). Technical change and incorporated R&D in the service sector. *Research Policy*, 27(7): 655-675.
- Angelmar, R. (1990) Product innovation: A tool for competitive advantage. *European Journal of Operational Research*, 47, 2, 182-189.
- Balasubramanian, N., & Lee, J. (2008). Firm age and innovation. *Industrial and Corporate Change*, 17(5), 1019-1047.

- Barge-Gil, A., Nieto, M.J. and Santamaría, L. (2011). Hidden innovators: the role of non-R&D activities. *Technology Analysis & Strategic Management*, 23, 4, 415-432.
- Baron, R. M., Kenny, D. A., 1986. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*. 51, 1173-1182.
- Bayona-Sáez, C. and García-Marco, T. (2010). Assessing the effectiveness of the Eureka Program. *Research Policy*, 39, 10, 1375-1386.
- Bishop, K., Mason, G. and Robinson, C. (2009) Firm growth and its effects on economic and social outcomes, National Institute of Economic and Social Research.
- Blundell, R., Griffith, R., & Van Reenen, J. (1999). Market share, market value and innovation in a panel of British manufacturing firms. *The Review of Economic Studies*, 66(3), 529-554
- Brown, S. and Warner, J. (1980). Measuring Security Price Performance. *Journal of Financial Economics*, 8:205-258.
- Camacho, J. A., and Rodriguez, M. (2008). Patterns of Innovation in the Service Sector: Some Insights From the Spanish Innovation Survey. *Economics of Innovation and New Technology*, 17(5), 459-471.
- Casper, S., Lehrer, M. and Soskice, D. (1999), Can High-technology Industries Prosper in Germany? Institutional Frameworks and the Evolution of the German Software and Biotechnology Industries, *Industry & Innovation*, 6, 1, 5-24.
- Chan, A., Go, F. M., and Pine, R. (1998). Service innovation in Hong Kong. Attitudes and practice. *The Service Industries Journal*, 18(2), 112–124.

- Chaney, P. K., & Devinney, T. M. (1992). New Product Innovations and Stock Price Performance. *Journal of Business Finance Accounting*, 19(5), 677-695.
- Clausen, T.H. and Pohjola, M. (2013). Persistence of product innovation: comparing breakthrough and incremental product innovation, *Technology Analysis & Strategic Management*, 25, 4, 369-385.
- Cooke, P. (2001), New economy innovation systems: biotechnology in Europe and the USA, *Industry & Innovation*, 8, 3, 267-289.
- Criscuolo, P. Nicolaou, N. and Salter, A. (2012). ‘The elixir (or burden) of youth? Exploring differences in innovation between start-ups and established firms’, *Research Policy*, 41, 2, 319-333.
- Damijan, J.P., Kostevc, C. and Rojec, M. (2012). Does innovation help the good or the poor performing firms?, *Economics Letters*, 115, 2, 190-195.
- Deeds, D.L., Decarolis, D. and Coombs, J.E. (1997), The impact of firm-specific capabilities on the amount of capital raised in an initial public offering: Evidence from the biotechnology industry, *Journal of Business Venturing*, 12, 1, 31-46.
- Delgado-Verde, M., Martín-de-Castro, G., Navas-López, J.E. and Cruz-González, J. (2011). Capital social, capital relacional e innovación tecnológica. Una aplicación al sector manufacturero español de alta y media-alta tecnología, *Cuadernos de Economía y Dirección de la Empresa*, 14, 4, 207-221.
- Eberhart, A. C., Maxwell, W. F., & Siddique, A. R. (2004). An Examination of Long-Term Abnormal Stock Returns and Operating Performance Following R&D Increases. *Journal of Finance*, 59, 2, 623-650.
- Fagerberg, J., Mowery, D.C., Nelson, R.R., 2004. *The Oxford Handbook of Innovation*. Oxford University Press, Oxford.

- Fetterhoff, T.J.; Voelkel, D. (2006), Managing Open Innovation in Biotechnology, *Research-Technology Management*, 49, 3, 14-18.
- Frankelius, P. (2009), Questioning two myths in innovation literature, *Journal of High Technology Management Research*, Vol. 20, No. 1, pp. 40–51.
- Freel, M.S. (2000) Do small innovating firms outperform non-innovators?, *Small Business Economics*, 14, 3, 195-205.
- Geroski, P., Machin, S., & Van Reenen, J. (1993). The Profitability of Innovating Firms. *The RAND Journal of Economics*, 24(2), 198-211
- Gertler, M.S. and Levitte, Y.M. (2005), Local Nodes in Global Networks: The Geography of Knowledge Flows in Biotechnology Innovation, *Industry & Innovation*, 12, 4, 487-507.
- Gomez, J.C. (2001). Rentabilidad y liquidez alrededor de la fecha de desdoblamiento de las acciones, *Investigaciones Económicas*, 25, 1, 171-202.
- Gunday, G., Ulusoy, G., Kilic, K., Alkan, L. (2011). Effects of innovation types on firm performance, *International Journal of Production Economics*, 133 (2), 662-676.
- Guo, B., Gao, J. and Chen, X. (2013). Technology strategy, technological context and technological catch-up in emerging economies: industry-level findings from Chinese manufacturing, *Technology Analysis & Strategic Management*, 25, 2, 219-234.
- Hahn, S. (2010). Competition, comparison, and innovation, *Economics Letters*, 106, 2, 122-124.
- Hall, B., & Oriani, R. (2006). Does the market value R&D investment by European firms? Evidence from a panel of manufacturing firms in France, Germany, and Italy. *International Journal of Industrial Organization*, 24(5), 971-993.

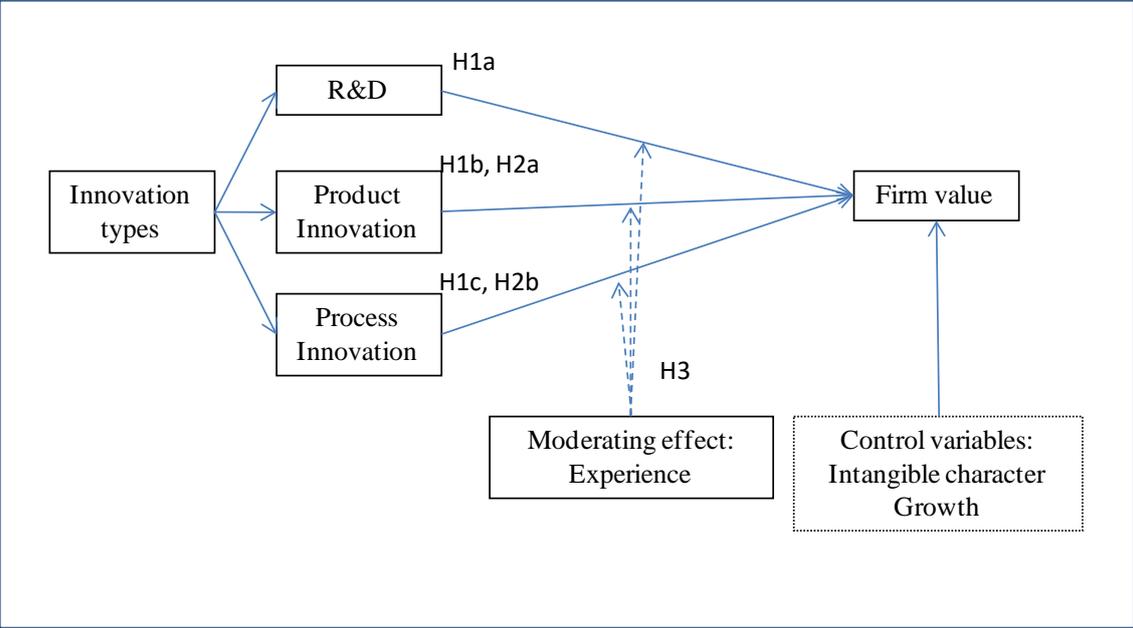
- Hall, C. M., and Williams, A. M. (2008). *Tourism and innovation*. London: Routledge.
- Hjalager, A. M. (2002). Repairing innovation defectiveness in tourism. *Tourism Management*, 23(5), 465-474.
- Hjalager, A.M. (2010). A review of innovation research in tourism. *Tourism Management*, 31, 1–12.
- Huergo, E., & Jaumandreu, J. (2004). Firms' age, process innovation and productivity growth. *International Journal of Industrial Organization*, 22(4), 541-559.
- Katzy, B., Turgut, E., Holzmann, T. and Sailer, K. (2013). Innovation intermediaries: a process view on open innovation coordination, *Technology Analysis & Strategic Management*, 25, 3, 295-309.
- Ma, T., Porter, A.L., Guo, Y., Ready, J., Xu, C. and Gado, L. (2014). A technology opportunities analysis model: applied to dye-sensitised solar cells for China, *Technology Analysis & Strategic Management*, 26, 1, 87-104.
- Máñez, J., Rincón, A., Rochina, M. and Sanchos, J. (2005). Productividad e I+D: un análisis no paramétrico, *Revista de Economía Aplicada*, 39, 47-86.
- Mansury, M.A., Love, J.H., 2008. Innovation, productivity and growth in US business services: a firm-level analysis. *Technovation* 28 (1), 52–62.
- Martinez-Senra, A.I., Quintás, M.A., Sartal, A. and Vázquez, X.H. (2013). ¿Es rentable «pensar por pensar»? Evidencia sobre innovación en España, *Cuadernos de Economía y Dirección de la Empresa*, 16, 2, 142-153.
- Mason, G., Bishop, K., & Robinson, C. (2009). Business Growth and Innovation - The wider impact of rapidly-growing firms in UK city-regions. *Technology*. NESTA.
- McMillan, G.S., Narin, F. and Deeds, D.L. (2000). An analysis of the critical role of public science in innovation: the case of biotechnology, *Research Policy*, 29, 1, 1–8.

- McWilliams, A. and Siegel, D. (1997). Event studies in management research: theoretical and empirical issues, *Academy of Management Journal*, 40(3), 626-57.
- Naranjo-Gil, D. (2009). The influence of environmental and organizational factors on innovation adoptions: Consequences for performance in public sector organizations, *Technovation*, 29, 12, 810-818.
- Natsukawa, T., Gemba, K. and Ishida, S. (2013). The timing of interorganisational collaborations in an emerging biopharmaceutical field: evidence from Japan in comparison to the remaining RNAi field, *Technology Analysis & Strategic Management*, 25, 5, 583-597.
- Park, S.H. and Kim, D. (1997), Market valuation of joint ventures: Joint venture characteristics and wealth gains, *Journal of Business Venturing*, 12, 2, 83-108.
- Rose, C.; Cronin, J.; Schwartz, R. (2007), Communicating the Value of Your Intellectual Property to Wall Street, *Research-Technology Management*, 50, 2, 36-40.
- Sahra, S.A. (1996), Technology strategy and new venture performance: A study of corporate-sponsored and independent biotechnology ventures, *Journal of Business Venturing*, 11,4, 289-321.
- Sharma, S., Durand, R.M., Gur-Arie, O., 1981. Identification and analysis of moderator variables, *Journal of Marketing Research*, 18(3), 291-300.
- Sorensen, J. B. and Stuart, T. E. (2000). Age, Obsolescence, and Organizational Innovation. *Administrative Science Quarterly*, Vol. 45, No. 1, pp. 81–112.
- Su, Z., Xie, E., Liu, H. and Sun, W. (2013), Profiting from product innovation: The impact of legal, marketing, and technological capabilities in different environmental conditions, *Marketing Letters*, 24:261-276.

- Tether, B.S. (2005) 'Do service innovate (differently)? Insights from the European Inn barometer survey', *Industry and Innovation*, 12, 2, 153–184.
- Tether, B.S., Hipp, C. and Miles, I. (2001). Standardisation and particularisation in services: evidence from Germany, *Research Policy*, 30(7): 1115-1138.
- Innovation in services
- Toivanen, O., Stoneman, P., and Bosworth, D. (2002) Innovation and market value of UK firms, 1989-1995. *Oxford Bulletin of Economics and Statistics*, 64, 39-61.
- Trigo, A. and Vence, X. (2012). Scope and patterns of innovation cooperation in Spanish service enterprises, *Research Policy*, 41, 3, 602-613.
- Trippel, M. and Tödttling, F. (2007), Developing Biotechnology Clusters in Non - high Technology Regions—The Case of Austria, *Industry & Innovation*, 14, 1, 47-67.
- Tussyadiah, I.P. (2013), Toward a Theoretical Foundation for Experience Design in Tourism, *Journal of Travel Research*, forthcoming.
- Victorino, L., Verma, R., Plaschka, F., and Dev, C. (2005). Service innovation and customer choices in the hospitality industry. *Managing Service Quality*, 15(6), 555–576.
- Walsh, K., Enz, C. A., and Canina, L. (2008). The impact of strategic orientation on intellectual capital investments in customer service firms. *Journal of Service Research*, 10(4), 300–317.
- Weidenfeld, A., Williams, A.M., Butler, R.W. (2010). Knowledge transfer and innovation among attractions. *Annals of Tourism Research*, 37(3), 604–626.
- Wolff, M. F.(2006), Southeast Asia Drives for *Biotech* Supremacy, *Research-Technology Management*, 49, 1, 2-8.

- Yam, R.C.M., Lo, W., Tang, E.P.Y. and Lau, A.K.W. (2011). Analysis of sources of innovation, technological innovation capabilities, and performance: An empirical study of Hong Kong manufacturing industries. *Research Policy*, 40, 3, 391-402.
- Zach, F. (2012). Partners and Innovation in American Destination Marketing Organizations, *Journal of Travel Research*, 51, 4, 412-425.
- Zach, F. and Fesenmaier, D. R. (2009). Innovation in Tourism: Destination Marketing Organizations. *E-review of Tourism Research*, 7, 1, online article.

**Figure 1. Innovation types and firm value**



**Table 1. Variables and measurements**

Variable		Measurement
R&D innovation type (R&D <sub>i</sub> )		Dummy variable (1 if R&D and 0 otherwise)
Product innovation type (PDI <sub>i</sub> )		Dummy variable (1 if Product innovation and 0 otherwise)
Process innovation type (PCI <sub>i</sub> )		Dummy variable (1 if Process innovation and 0 otherwise)
Firm value (abnormal returns: AR <sub>i</sub> )		See equation 2
Firm growth (Gr <sub>i</sub> )		Growth=1/3·[ln(turnover <sub>t-1</sub> / turnover <sub>t-3</sub> )].
Experience (Exp <sub>i</sub> )		Age of the firm
Intangible character (Int <sub>i</sub> )		Dummy variable (1 if the firm includes service components and 0 if it is a pure manufacturer)

**Table 2. Effect of innovation-related activities on firm value**

Event window	Garch Abnormal Returns	Brown and Warner's test	Theil Abnormal Returns	Brown and Warner's test
-1	0.00546	2.278	0.00545	2.472
0	-0.00350	-0.780	-0.00162	-0.371
+1	-0.00357	-0.953	-0.00441	-0.971

**Table 3. Effect of innovation types on excess returns**

Variable	Parameters from Garch abnormal returns	Parameters from Theil abnormal returns
Product innovation	-0.138* (0.049)	-0.141* (0.049)
Process innovation	-0.109* (0.046)	-0.118* (0.046)
Product innovation x experience	0.002* (0.0007)	0.002* (0.0007)
Process innovation x experience	0.001* (0.0008)	0.001* (0.0008)
Experience	-0.002* (0.0007)	-0.002* (0.0007)
Intangible carácter	-0.043* (0.017)	-0.043* (0.017)
Growth	0.016 (0.008)	0.010 (0.008)
Constant	0.141* (0.050)	0.144* (0.050)
R-squared	0.420	0.446

\* =p&lt;0.05

**Table 4. Main results of the hypotheses tested**

<b>Hypothesis</b>	<b>Result</b>
<b>H.1a.:</b> <i>R&amp;D leads to an increase in firm value.</i>	Accept
<b>H.1b.:</b> <i>Product innovation leads to an increase in firm value.</i>	Accept
<b>H.1c.:</b> <i>Process innovation lead to an increase in firm value.</i>	Accept
<b>H.2a.:</b> <i>R&amp;D (as a promise of future tangible items) has an effect on firm value which is different from product innovations (which is already tangible).</i>	Accept
<b>H.2b.:</b> <i>R&amp;D (as a promise of future tangible items) has an effect on firm value which is different from process innovations (which is already tangible).</i>	Accept
<b>H.3.:</b> <i>Firm's experience exerts a moderator effect on the impact of innovation on firm value.</i>	Accept

