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.

Nicolau, J.L. y Santa María, M.J. (2015) "Battle royal in biotechnology: R&D vs product vs process innovations", ***Technology Analysis & Strategic Management***, 27, 5, 503-513.

http://www.tandfonline.com/doi/abs/10.1080/09537325.2015.1012056

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; Trippl 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; Srinavasan 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:

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

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); α_i=returns on the shares of company *i* independent of those of the market; β_i= sensitivity of returns on the share *i* to variations in market returns; and

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

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

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

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

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

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

$$h_{it}=c_i+\lambda_i\varepsilon^2_{it-1}+\gamma_ih_{it-1} \qquad (3)$$

where c_i, λ_i and γ_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 β 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 β with the median slope and compute the values of $\hat{\alpha}_t$ for all data pairs; and vi) estimate α 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

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

where μ_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·[ln(turnover$_{t-1}$/ 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 (χ^2=3.46; p>0.05 and χ^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 [χ^2=1.40; p>0.05 and χ^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.

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Figure 1. Innovation types and firm value

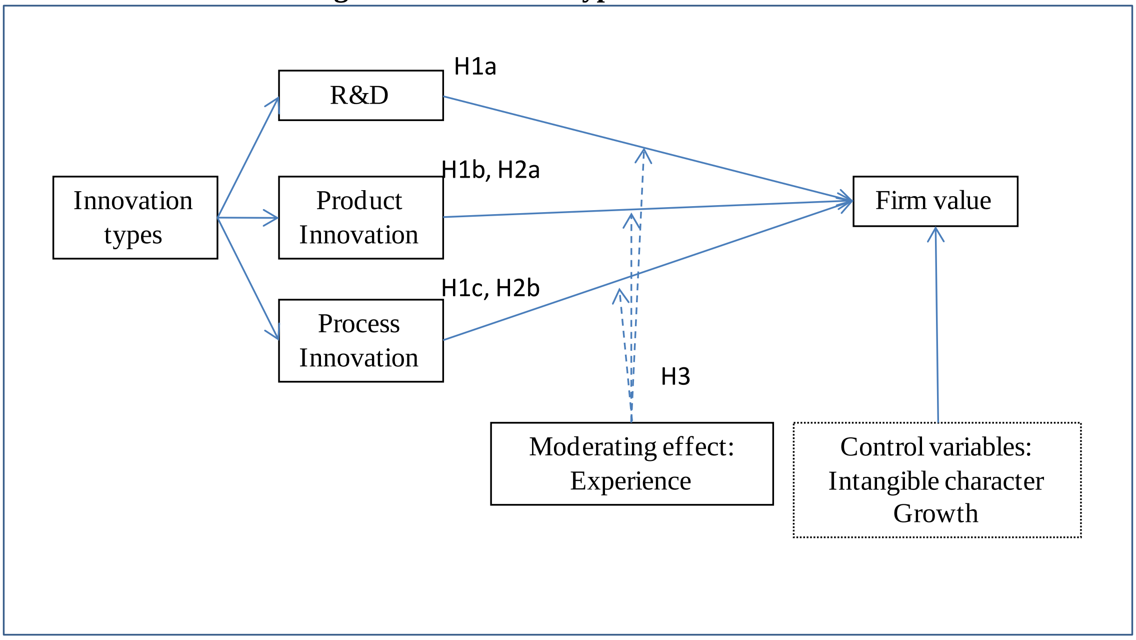

Table 1. Variables and measurements

Variable	Measurement
R&D innovation type ($R\&D_i$)	Dummy variable (1 if R&D and 0 otherwise)
Product innovation type (PDI_i)	Dummy variable (1 if Product innovation and 0 otherwise)
Process innovation type(PCI_i)	Dummy variable (1 if Process innovation and 0 otherwise)
Firm value (abnormal returns: AR_i)	See equation 2
Firm growth (Gr_i)	Growth=$1/3\cdot[\ln(turnover_{t-1}/ turnover_{t-3})]$.
Experience (Exp_i)	Age of the firm
Intangible character (Int_i)	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*	-0.141*
	(0.049)	(0.049)
Process innovation	-0.109*	-0.118*
	(0.046)	(0.046)
Product innovation x experience	0.002*	0.002*
	(0.0007)	(0.0007)
Process innovation x experience	0.001*	0.001*
	(0.0008)	(0.0008)
Experience	-0.002*	-0.002*
	(0.0007)	(0.0007)
Intangible carácter	-0.043*	-0.043*
	(0.017)	(0.017)
Growth	0.016	0.010
	(0.008)	(0.008)
Constant	0.141*	0.144*
	(0.050)	(0.050)
R-squared	0.420	0.446

*=$p<0.05$

Table 4. Main results of the hypotheses tested

Hypothesis	Result
H.1a.: *R&D leads to an increase in firm value*.	Accept
H.1b.: *Product innovation leads to an increase in firm value*.	Accept
H.1c.: *Process innovation lead to an increase in firm value*.	Accept
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).*	Accept
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).*	Accept
H.3.: Firm's experience exerts a moderator effect on the impact of innovation on firm value.	Accept