THE DETERMINTANTS OF STRATEGIC CHOICE OVER OPENNESS: SCALE-BASED COMPETITION, SLACK RESOURCES AND THE INNOVATIVENESS OF PRODUCT PORTFOLIO

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Abstract:
This paper seeks to explore the drivers of the rate of openness in firms' innovation processes. The study aims to underscore the role played by scale economies, the innovativeness of product portfolio, the existence of financial slack, and the rate of internal change in operations. We find that competitive pressure due to economies of scale and possession of financial slack encourage firms to pursue a more open innovation strategy, while a valuable product portfolio embedding superior technologies and the rate of commitment toward internal process changes make firms refrain from being open innovators. To better address the choice toward openness, we apply a more fine-grained measure as distinguishing three types of innovation strategies: open, semi-open, and the traditional closed model. For our empirical analysis, we take data from the 2008 PITEC database, which is the Spanish correspondence of the Community Innovation Survey, and apply a sample of 2148 firms. The econometric model useful to accommodate multiple categorical responses implied by our model specification, is the multinomial logit model.

Keywords: open innovation, scale-based pressure, slack resources, product portfolio, large sample size

1. INTRODUCTION

A relevant body of research in the open innovation tradition tries to seek the factors that can motivate or discourage firms from increasing the rate of openness in their innovation processes. Prior works revealed that largely firm size, complementary assets, R&D intensity, and network externalities were at the forefront of empirical investigations (Barge-Gil, 2010; Bonaccorsi *et al*., 2006; Harison & Koski, 2010; Henkel, 2006). These results notwithstanding, there might be other potential issues at work pointed out by the business press and anecdotal evidences, such as scale economies, the innovativeness of product portfolio, the existence of financial slack, and the rate of internal change in operations (Alexy *et al*., 2013; Chesbrough, 2007; Chiaroni *et al*., 2011; Dobrev & Carroll, 2003; The Economist, 2011a). What are then the further drivers of the rate of openness in innovative activities? In order to address our research question, we draw on a population of 2148 firms taken from the Spanish Community Innovation Survey that broadens the relatively low number of papers with large datasets in the open innovation perspective.

2. THEORY AND HYPOTHESES

Prior literature documented a great many industries in which scale economies impinge a pervasive force in organizational evolution. Notable examples embrace automobile producers in the U.S. and in Europe (Dobrev & Carroll, 2003), the U.S. television receiver industry (Klepper & Simmons, 2000; The Economist, 2011a), the beer-brewing industry (Carroll & Swaminathan (2000), the worldwide container shipping industry (The Economist, 2011b), and the smartphone industry (The Economist, 2011a). The aftermath of scale-competition is the worsened position of smaller firms vis-á-vis their larger rivals. Such a structural disadvantage appears in the face of higher average costs that can lead to internal inefficiency. This can range from supplier and buyer markets to hindrance on the labor market by the inability to offer favorable wage conditions and overall job security in relation to large rival organizations (Dobrev & Carroll, 2003; Dobrev, Kim & Carroll, 2002; The Economist, 2011ab). Additional source of selection pressure on smaller entities originating from scale differences lies in the observation that large firms often receive a special treatment from regulatory bodies and policymakers which convert them advantage in intrapopulation competition (Nelson & Winter, 1982). Further, not only economies of scale but economies of scope can also be associated to larger relative size as a consequence of grouping distinct complementary activities within firm boundaries. For instance, Samsung profits from the so-called brand halo effects through competing in related technology intensive industries (The Economist, 2011a).

Our primary objective here is to demonstrate the potential strategic importance of distinguishing absolute and relative size[1] where this latter represents the extent of economic advantages to lower costs, political and institutional advantages and important complementarities emanating from scale-competition. By so doing, we parse out results of pure size effect found in prior works (Barge-Gil, 2010; Harison & Koski, 2010). Because economies of scale drive the underlying competition in the above listed industries, we believe that it also has to exert an effect on firms' choice toward openness of innovation policy.

Our conjecture aligns well with the observation made by Klepper and Simmons (2000), who revealed that major product and process innovations were mainly produced by large incumbent organizations in the U.S. television receiver industry. We posit that scale competition does affect smaller competitors in their choice over the degree of openness by dividing industry population into two distinct groups: although one subgroup of scale-competition sensitive rivals opts the traditional closed innovation approach with in-house R&D activities, we can discern another subgroup that gives discrepant answer to competitive problems due to scale pressure. Recognizing the impossibility to withstand head-to-head competition with larger ones, prominent members of the second subgroup aim to capture benefits from open innovation in terms of costs, idea and knowledge acquisition or external use of internally deployed resources in the open innovation spirit (Chesbrough, 2007). Such strategic attitude accords well with previous works that highlight openness in not only imposing challenges but to potentially sourcing various benefits for small firms (Barge-Gil, 2010; Giarratana, 2003; Lee *et al*., 2009; Nieto & Santamaría, 2010, Zahra et al., 2002).

[1] Dobrev and Carroll (2003) provide a detailed discussion regarding the theoretical and analytical relevance of dividing organizational size into two types.

Hypothesis 1: Higher degrees of competitive pressure make firms to be selected either with high rates of openness, or with closed modes in their innovation strategies.

Organisational slack has the peculiar feature that accrues to firms under more profitable spells and grants them flexibility as external environment is to jeopardy the formerly agreed internal commitments and aspirations (Cyert & March, 1963; Levinthal & March, 1981; Meyer, 1982). Literature on slack resources reveal as well that it works as a cushion in providing excess resources for firms to induce or impel changes in firm strategy (Bourgeois, 1981). Scholars from the behavioural tradition emphasize that the level of slack is associated with risk taking and so experimentation, which impacts the rate of innovativeness (Nohria & Gulati, 1996) and performance (Bromiley, 1991; George, 2005; Singh, 1986).

Open innovation is a gradual process and requires different types of organizational investments in structures, operations, control processes (for instance progress evaluation), knowledge and technology management tracking systems (Alexy et al., 2013; Chiaroni et al., 2011; Huston & Sakkab, 2006). To such investments, pecuniary resources would be necessitated at the beginning to induce the process until the revenues obtained surpass the costs incurred (The Economist, 2011a). Accordingly, we predict that the possession of financial slack resources positively influences the organizational choice toward more openness in innovative activities.

Hypothesis 2: Firms with higher amount of financial slack resources will exhibit more openness in their innovation strategies.

The management of product portfolio is of key importance for firms (Fosfuri & Giarratana, 2007; Eggers, 2012; Sorenson, 2000). According to the literature, a broad product scope is particularly useful during higher rates of environmental uncertainty (Dobrev *et al*., 2002) and for the application of hedging strategy against risk of losses (Sorenson, 2000). Greater product proliferation is suitable to raise entry barriers (Lancaster, 1990) and capture demand synegies through a ‘one-stop shopping’ product offer (Fosfuri & Giarratana, 2007).

In competitive industries, rivalry faced by firms is associated with poorer performance and activates internal organizational learning processes (Barnett & Sorenson, 2002). Such internal learning processes can entail that firms commit resources to continuously refine their product offerings that fit more closely the needs and expectations of their customers. However, industry wisdom suggests that firms do complement their internal channels and often prefer to be exposed of outside ideas (Chiaroni *et al*., 2011; Sakkab, 2002). From the organisational learning tradition, March’s (1991) framework on the exploitation/exploration dichotomy also argues that to a larger or smaller extent firms are better off by simultaneously being committed not only to internal R&D (using current competences) but also to external orientation through developing new knowledge.

We define quality of product portfolio as consisting of valuable products that display high level of innovativeness, and thus sell best on the market. We argue that firms having developed a product portfolio of valuable and innovative products turn to limited rate of openness, and so doing also resort to internal activities. First, having a valuable portfolio of products and turning to excessive openness, could produce a product cannibalization effect (Garud & Kumaraswamy, 1993) inside existing product categories when the firm updates too often its product offerings. Second, excessive openness implies the use of numerous external channels that could entail the risk of knowledge dissipation for the organisation, especially under reduced appropriability regimes (Gans & Stern, 2003; Teece, 1986). Third, costs of open innovation explained in Almirall and Casadeus-Masanell (2010) can greatly confine the developer firm’s ability to establish the product’s technological trajectory (including the features of the product) by losing some control compared to closed design.

Hypothesis 3: Firms with valuable products that sell best on the market tend to avoid full openness in their innovation strategies.

Damanpour (1991) defines managerial attitude toward internal change as the extent to which managers are in favour of change inside the organisational boundaries. We posit that managers that initiate a process of internal change toward operations for major production capacity, and savings on material use, costs and energy will refrain from involving their organizations into higher degrees of

openness. The reason is that open innovation requires substantial investments from many parts of the organization (Chiaroni et al., 2011), and can encompass cultural issues as well (van de Vrande et al., 2009), which introduces inertia against change. Documentary evidence on Procter & Gamble buttresses the conjecture that higher degrees of external change do not fit to opening up a company's business model, and can forfeit operational discipline, ultimately deteriorating earnings numbers that investors expect (Chesbrough, 2007). In addition, Koput's (1997) model of innovative search highlights that receiving extreme amount of ideas to process might eventually inhibit the rate of implementation owing to scarce attention.

Hypothesis 4: Firms that witness unfolding internal change within their boundaries tend to avoid full openness in their innovation strategies.

3. EMPIRICAL ANALYSIS

3.1. Data

We resort to the PITEC database to serve as our test-bed. The dataset is drawn from the Community Innovation Survey gathered in Spain, in 2008, and managed by the Spanish National Statistics Institute. Many previous works used this database (Barge-Gil, 2010; Escribano *et al*., 2009), or its U.K. counterpart (Laursen & Salter, 2006). Due to sample selection considerations, we only included those firms that performed R&D activities, i.e. expended a positive amount of resources on innovation activities. Table 1 demonstrates that our sample embraces more than 2100 firms.

3.2. Dependent variables

Studying open source software industry, Henkel (2006) operationalized open innovation activities as the share of revealed source code, restricted to the interval [0-100%]. Using the same setting, Bonaccorsi *et al*. (2006) and Harison and Koski (2010) use categorical 0-1 variables to distinguish firms that are more or less open source oriented. To appropriately grasp openness through a more fine-grained measure, we follow Barge-Gil (2010) in distinguishing open, semi-open and closed innovators. Open innovators (OPEN) generate their innovations principally via interaction with other firms, or exclusively by the partners. The middle category represented by SEMI-OPEN incorporates those organizations that develop innovations principally in-house, but eventually worked together with others or acquired external R&D. The innovation performance of firms belonging to the third category (CLOSED) is completely restricted to their own innovative efforts without ever being committed to cooperation or technology acquisition. The categorization, identifying the three grades of openness, facilitates to follow firm strategies in a more adequate way. According to Table 1, our sample embraces 690, 545 and 913, open, semi-open and closed innovators, respectively.

Table 1. Number of firms in each category of openness

Degree of openness			
Open	Semi-open	Closed	Total
690	545	913	2148

3.3. Variables of theoretical interest

The variable CPRESSURE aims to grasp competitive pressure. Following Dobrev and Carroll (2003), it is operationalized by the following formula

$$CP_{it} = \sum_{S_{jt}>S_{it}} [(S_{it} - S_{min})^{-1/4} - (S_{jt} - S_{min})^{-1/4}],$$

where S_{it} stands for the sales volume of firm *i*. The variable measures the aggregate distance of firm *i* from all larger firms *j* inside its respective industry, applying an adjustment with the smallest firm. As the formula shows, the greater the number of larger rivals, the greater the competitive pressure the focal firm faces. Firms in questionnaire denote the percent of R&D funds that originate from five bigger categories (funds of the same firm, by other Spanish firms, public financing, other national sources and foreign funds), and in total from 18 sources. Using all the sources, we built FIN_SLACK, a Herfindhal measure that when taking a high value represents a low level of financial slack. The quality

of product portfolio (QPP) is measured as the fraction of the firm's turnover associated both to products new to the world market and to products new to the firm. Thus, QPP simultaneously incorporates market success and high level of technological content. Firms rate on a four-point scale, the effectiveness of five different methods that can undertake toward the adjustment of their internal operations. The five areas embrace improvement on flexibility and capacity of production, and achievement of savings on material use, material costs and energy. For the last core variable, MACH_INT, we sum up the five scores, and rescale them, so that the resulting index of managerial attitude toward change of internal affairs varies between 0 (minimum internal change) to 1 (maximum internal change). The notion of this transformation is taken from prior studies (Cassiman & Veugelers, 2002; Escribano *et al*., 2009).

3.4. Control variables

We introduce a series of control variables to distinguish effects different from our variables of theoretical interest. We control for the size of the actual product market (GEO_MARK). GEO_MARK takes the values from 1 to 4, with 1 corresponding to 'local', 2 to 'regional', 3 to 'national', and 4 to 'international'. The sector in which the firm competes, filters access to critical resources (Barge-Gil, 2010; Laursen & Salter, 2006). Therefore, we classify firms into 4 categories according to the level of technological level, and create the dummy variables low-tech (LOW_TECH), low- to medium-tech (LOW_MEDIUM), medium- to high-tech (MEDIUM-HIGH), and high-tech (HIGH_TECH). By so doing, we pursue the OECD classification (OECD, 2005) and earlier studies (Barge-Gil, 2010). It is important to highlight that we apply the high-tech sector as reference category in our specifications. We use the number of employees as a measure of firm's (absolute) size (ABS_SIZE) that clears up its effect from relative size considerations. We also include a measure of R&D intensity (RD_INT) as the ratio of firm R&D expenditure and firm sales. Table 2 displays the basic statistics for the variables used for the whole sample, and with regard to the different categories of the dependent variable.

Table 2. Descriptive statistics

	All sample		Open		Semi-open		Closed	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
CPRESSURE	0.93	1.80	0.94	1.99	0.66	1.56	1.08	1.76
FIN_SLACK	0.88	0.19	0.83	0.22	0.85	0.20	0.95	0.14
QPP	39.24	36.69	34.76	36.15	39.57	35.44	42.43	37.50
MACH_INT	0.61	0.25	0.60	0.26	0.64	0.23	0.61	0.24
GEO_MARK	3.59	0.74	3.61	0.71	3.67	0.66	3.52	0.79
LOW_TECH	0.23	0.42	0.25	0.43	0.21	0.41	0.23	0.42
LOW_MEDIUM	0.15	0.36	0.14	0.35	0.15	0.36	0.15	0.36
MEDIUM_HIGH	0.47	0.50	0.47	0.50	0.48	0.50	0.47	0.50
ABS_SIZE	231.61	628.26	219.13	467.58	341.08	857.01	175.69	561.73
RD_INT	0.11	1.96	0.23	3.45	0.07	0.18	0.05	0.17

3.5. Methodology

The response variable represents the choice of a firm *i* among the three different alternatives: closed, semi and open innovators, denoted as *j* = 1, 2 and 3, respectively. An econometric model useful for multiple categorical responses is the multinomial logit model. The model can be motivated from the random utility model defined as

$$U_{ij} = \mathbf{z}_{ij}^{t}\theta + \epsilon_{ij} \quad .$$

If choice *k* is selected implies that

$$U_{ik} > U_{il} \text{ for all } l \neq k.$$

McFadden (1974) has showed that if and only if all disturbances are independent and identically distributed with Gumbel (type 1 extreme value distribution) the probability of choice *j* can be written as

$$P_{ij} = P(Y_i = j) = \frac{exp(\mathbf{z}_{ij}^t \theta)}{\sum_{j=1}^{3} exp(\mathbf{z}_{ij}^t \theta)}, \quad j = 1, 2, 3$$

.

Since our random utility model depends only on the individual-specific characteristics of the firms, the expression above takes the form (Greene, 2008)

$$P(Y_i = j|\mathbf{w}_i) = \frac{exp(\mathbf{w}_i^t \alpha_j)}{\sum_{j=1}^{3} exp(\mathbf{w}_i^t \alpha_j)}, \quad j = 1, 2, 3$$

.

Maximum likelihood estimators can be derived from the log-likelihood function defined as

$$\ln L = \sum_{i=1}^{N} \sum_{j=1}^{3} d_{ij} \ln \frac{exp(\mathbf{w}_i^t \alpha_j)}{\sum_{j=1}^{3} exp(w_i^T \alpha_j)},$$

where d_{ij} = 1, if alternative *j* is chosen by firm *i*, and 0 otherwise. We use the *mlogit* package of the statistical software *R* throughout all computations in the study, for which the maximum likelihood estimators are numerically approximated using the Newton-Raphson method.

4. RESULTS AND DISCUSSION

Table 3 and 4 provide the estimation results. Our first hypothesis gains support as the variable CPRESSURE is significant in both models. Accordingly, we can observe the split of organizational population into two subgroups. When experiencing higher degrees of competitive pressure within the respective industry, firms belonging to the first subgroup choose a higher rate of openness in innovation strategy, whilst firms in the other subgroup opt for a traditional closed business model. Through the joint inclusion of CPRESSURE and ABS_SIZE, we could parse out effects associated to economies of scale and scope, providing a value addition to prior literature. The choice of the first subgroup toward openness confirms earlier works in which smaller firms do commit open innovation practices (Barge-Gil, 2010; Bonaccorsi *et al.*, 2006; Henkel, 2006; Harison & Koski, 2010; van de Vrande *et al.*, 2009). The variable FIN_SLACK is significant and in the expected sign lending support for Hypothesis 2. Firms possessing financial slack (at low values of the variable) pursue a more open innovation strategy preferring open to semi-open and closed, and semi-open to closed innovation strategies. This finding regarding the positive link between greater financial latitude due to slack and the rate of innovativeness coincides with Nohria and Gulati (1996).

Table 3. Results of multinomial logit model (reference category = SEMI-OPEN)

Dependent variable: 3 (OPEN)	Coefficient	Std error	
Constant	1.13	0.44	*
CPRESSURE	0.10	0.05	*
FIN_SLACK	-0.51	0.28	†
QPP	-0.005	0.002	**
MACH_INT	-0.60	0.24	*
GEO_MARK	-0.03	0.09	
LOW_TECH	0.34	0.19	†
LOW_MEDIUM	0.12	0.21	
MEDIUM_HIGH	0.15	0.17	
ABS_SIZE	-0.0002	0.0001	†
RD_INT	0.16	0.20	

Dependent variable: 1 (CLOSED)	Coefficient	Std error	
Constant	-1.38	0.47	**
CPRESSURE	0.18	0.05	***
SLACK_RES	3.16	0.33	***
QPP	0.00	0.00	
MACH_INT	-0.45	0.23	†
GEO_MARK	-0.22	0.08	**
LOW_TECH	0.03	0.19	
LOW_MEDIUM	0.14	0.20	
MEDIUM_HIGH	0.00	0.16	
ABS_SIZE	-0.0003	0.0001	**
RD_INT	-0.95	0.40	*

***, p-value < 0.001, ** p-value < 0.01, * p-value < 0.05, † p-value < 0.1
Log-Likelihood: -2169.4

Hypothesis 3 is also corroborated by results as the QPP variable displays significance in our models in the expected direction. Accordingly, firms with valuable products that embed superior technologies will refrain from being open innovators. Though as our data show, there is indifference between the strategic choices of setting semi-open or completely closed innovative activities. The coefficient of MACH_INT defines the rate of firms' commitment toward internal process changes. Data reveal that maintaining such an internal orientation, firms avoid full-blown open innovation and choose semi-open modes of innovation. In this sense, we complement former findings suggesting that a firm policy restrictive to openness set by managers can diminish open innovation orientation (Henkel, 2006). However, surprisingly there is no statistically significant difference implied by Table 4 (albeit the MACH_INT variable is negative, its effect turns out insignificant) between closed and open innovators emanating from the enhanced commitment for internal change. Thus, results only partly confirm our last hypothesis. We speculate that some firms embark to following open innovation and internal transformation of their productive processes at the same time, disregarding the detrimental trade-off implied by the literature (Chesbrough, 2007).

As far as it concerns our control variables, the estimates of the GEO_MARK variable report that firms with international market orientation tend to disregard closed innovation strategies, and thus become open and semi-open innovators. Dummies controlling for technological categories do not exhibit a clear pattern, except that low-technology firms attempt to opt more openness, probably to draw from the knowledge and technology pool of other firms (possibly coming from different industries), and to improve their competitive position. Organizations of the largest size are semi-open innovators. With regard to R&D-intensity, there is no statistically significant difference between open and semi-open innovators. Furthermore, more R&D-intensive firms are clearly not closed innovators but either semi-open or open.

Table 4. Results of multinomial logit model (reference category = CLOSED)

Dependent variable: 3 (OPEN)	Coefficient	Std error	
Constant	2.51	0.43	***
CPRESSURE	-0.08	0.04	*
FIN_SLACK	-3.67	0.31	***
QPP	-0.01	0.001	***
MACH_INT	-0.16	0.22	
GEO_MARK	0.19	0.07	*
LOW_TECH	0.31	0.18	†
LOW_MEDIUM	-0.02	0.20	
MEDIUM_HIGH	0.14	0.16	
ABS_SIZE	0.00	0.00	
RD_INT	1.11	0.38	**

*** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05, † p-value < 0.1
Log-Likelihood: -2169.4

5. CONCLUSIONS

In this paper we have investigated empirically the determinants of firms' strategic choice over openness. To this end, we distinguished three types of innovation strategies: open, semi-open, and the traditional closed one. We took our data from the 2008 PITEC database, which is the Spanish correspondence of the Community Innovation Survey. Our findings suggest that competitive pressure (aggregate distance from larger rivals in an industry), the possession of financial slack resources, a valuable product portfolio of superior technologies, and managerial attitude toward internal change are important factors in explaining strategic choice of becoming open, semi-open or closed innovators. As secondary findings, we show that firms with a higher international scope clearly favour open and semi-open modes of innovations disregarding closed innovation strategies. Further, the estimates of the absolute size variable altogether with relative size provide evidence that the effects of absolute and aggregate distance size are independent of one another.

The research agenda we set forth has implications for theory and practice. Complementing prior studies, we detected some specific organizational and within-industrial traits that had not been studied before. For this reason, the research presented here implies a theoretical value addition for the open innovation body of literature. Further, practitioners also benefit in the sense that they can tailor more appropriately their innovation strategies taking into considerations the highlighted organizational attributes. Our study is not exempt of limitations. One future avenue for further refining the current research is the application of longitudinal data that could offset the weaknesses of cross-sectional analysis.

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