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THE INTERPLAY OF INBOUND AND OUTBOUND INNOVATION AND ITS IMPACT ON FIRM GROWTH

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Abstract

This study investigates whether and how the interplay of inbound and outbound innovation activities affects firms? performance. We argue that these two forms of open innovation need to be examined simultaneously to enhance our understanding of open innovation and of its performance implications. Using a new measure of open innovation, both objective and continuous, we analyse a panel dataset including 322 European listed companies over a period of five years (2008-2012), meaning 1,181 firm-level observations in total. Our findings suggest that under certain conditions the interaction between inbound and outbound activities may indeed enhance firm performance.

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Abstract

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INTRODUCTION

This study investigates whether and how the interplay of inbound and outbound flows of knowledge affects firms' performance, measured in terms of sales growth. We argue that inbound and outbound knowledge flows need to be considered simultaneously to enhance our understanding of open innovation and its performance implications.

Operationally, we define open innovation activities as the acquisition and commercialization of *knowledge assets* - e.g. patents, copyrights, design models, etc. We acknowledge that these knowledge assets do not capture the entire range of open innovation activities a firm can engage in, as there might be other forms of collaboration we are not accounting for. Nevertheless, we believe the use of knowledge assets offers several advantages. In particular, they somehow objectively reveal a company commitment to make permeable the boundaries of its knowledge base, at the same time providing an economic measure of the actual significance of knowledge flows. In this study we draw on a panel dataset including 322 European listed companies headquartered in UK, Germany, France, Italy and Spain, tracked over five years (2008-2012), yielding a final dataset of 1,181 firm-year observations.

Our preliminary results suggest that under certain conditions the interaction between inbound and outbound activities may indeed enhance firm performance, provided that the

company recognizes that open innovation is not a shortcut for cost saving but rather a competitive strategy that requires significant investments.

Our findings offer several contributions. First, a better understanding of the conditions by which inward and outward knowledge flows are complementary or substitute extends the original paradigm of open innovation and help clarify the distinction between this paradigm and similar theoretical constructs (see for instance the critique of Trott et al., 2009). From an empirical perspective, we introduce a new measure of open innovation activities that is both objective and continuous. From a managerial standpoint, our findings offer insights on the optimization of investments in open innovation activities, and clarify the contingency factors that explain when the exclusive engagement in either inbound or outbound innovation is preferable, or when *viceversa* pursuing both is a better option.

The remainder of the paper is structured as follows. First we introduce the theoretical framework and discuss the key constructs underpinning the research setting. Second, we develop hypotheses on the separate and joint impact of inbound and outbound flows of knowledge on firm performance. Then, after describing the methodology we used, we illustrate the results of our panel regression. We conclude by acknowledging the key limitations of this study and by highlighting promising directions for further research.

BACKGROUND & HYPOTHESES DEVELOPMENT

Open Innovation is a broad construct embracing many aspects grounded in different research streams. A decade after Chesbrough's seminal contribution, the construct of open innovation has significantly evolved. Our study attempts to contribute to extant literature, considering both knowledge inflows and outflows. Specifically, we focus on the acquisition and commercialization of knowledge assets.

Inbound Flows of Knowledge

Inbound innovation is the practice of leveraging the discoveries of others, abandoning the idea of relying merely on the internal R&D (Chesbrough *et al.*, 2006). A number of contributions already showed its contribution to the enhancement of firms' competitive advantage (e.g. Laursen *et al.*, 2006; Tsai *et al.*, 2008). The openness to external sources of knowledge allows companies to feed their pipeline of ideas and projects by expanding the pool of opportunities available to them (Laursen *et al.*, 2006), increasing their innovativeness (Laursen *et al.*, 2006; Sandulli *et al.*, 2012).

Inbound innovation may take place through a number of modes. As previously mentioned, here we focus on open innovation pursued through the acquisition of knowledge assets (e.g. a patent), or via M&As, all aimed at internalizing capabilities developed by others. This is an increasingly popular strategy to develop new technologies, support innovativeness, and grow (Cassiman *et al.*, 2005; Lambe *et al.*, 1997; Valentini *et al.*, 2012).

. Hence we posit the following research hypothesis:

Hp1. Inbound flows of knowledge assets are positively associated with firm performance

Outbound Flows of Knowledge

Outbound open innovation is the practice of exploiting technology capabilities by leveraging on external paths of commercialization (Chesbrough, 2003). Empirical evidence is relatively scarce on this open innovation activity. Contributions are limited and findings are partially controversial (and largely based on out-licensing).

Most available studies, however, argue that outwards flows of knowledge tend to support firms' innovativeness and competitive advantages (Chesbrough, 2007; Lichtenthaler *et al.*, 2007b). Though this form of openness may weaken a firm's competitive position because of knowledge leakage, by selling or licensing knowledge assets companies can fully exploit their investments in R&D (Chesbrough, 2003; Zahra *et al.*, 2002).

Hence, the second research proposition arises as follows:

Hp2. Outbound flows of knowledge assets are positively associated with firm performance

Interaction between Inbound and Outbound Flows of Knowledge

As a third step, we investigate the possibility that inbound and outbound flows of knowledge jointly affect firm performance. Broadly speaking, activities and their potential interaction define three main types of relationship in the performance landscape (Catozzella *et al.*, 2014; Porter *et al.*, 2008): generic, substitute and complementary. The generic conjecture posits that investments in inbound innovation are not affected by choices in terms of outbound innovation, and *viceversa*. The substitutability view considers innovative initiatives as standalone activities, usually pursued as alternative drivers to grow (Catozzella *et al.*, 2014). By contrast, the third possible landscape – complementary activities – takes places if the simultaneous use of different inputs is more efficient (Rothaermel *et al.*, 2005).

Prior literature have largely ignored synergies – positive or negative – between inbound and outbound flows of knowledge in affecting firm performance (West *et al.*, 2014). Dahlander and Gann (2010) state that "*we lack substantive evidence about how firms can combine different ways of managing openness"* (p. 707). A body of literature supports the centrality of specialization processes within the innovation eco-system, and claims that companies tend to focus on outbound or - most frequently - inbound innovation only, rarely together (Bianchi *et al.*, 2010; Gronlund *et al.*, 2010; Lichtenthaler *et al.*, 2007a).

On the other hand, there also are convincing theoretical arguments that claim a synergy between high levels of both inbound and outbound openness (Cassiman and Valentini, 2015). We argue that this possibility is the most consistent with the above-discussed construct of open innovation, and with the type of knowledge transfer here considered (market transactions). The main explanations underpinning the above-mentioned complementarities are the following. First, open innovation is largely recognized as a mindset, a part of the corporate culture (Gassmann *et al.*, 2010). As such, it tends to influence several organizational routines across functions and departments, moving from isolated initiatives limited to one direction (inbound or outbound). Second, the firm that frequently deals with knowledge asset sales (or acquisitions), in the long run becomes more familiar with the technology market, meaning also more familiar with the expertise the company need to deal with market transactions: asset evaluation, negotiation, due diligence, contract agreements, and so on. Hence, we posit the following research hypothesis:

Hp3. The interaction between inbound and outbound flows of knowledge assets is positively associated with firm growth

METHODS

Our empirical methods entailed a panel regression analysis based on an original longitudinal dataset of 322 European listed companies over a period of five years (2008-2012). The dataset includes firms' financial indicators and measures of inwards and outwards flows of knowledge. These data were mainly obtained from firms' official annual reports, based on an in-depth analysis of their intangible assets records (Denicolai *et al.*, 2014). Many listed companies provide a detailed account of their intangible assets in their annual reports, including the breakdown by type of asset, their source, and their inbound and outbound flows in the previous year. The focus on listed companies offers several advantages, given the objective of our analysis. First of all, it allows collecting reliable and objective data about

firms' performance and open innovation activities, instead of self-reported measures traditionally used in studies investigating similar issues (such as the Community Innovation Survey). Second, all companies listed on European stock exchanges comply with the same 'International Financial Reporting Standards' (IFRS), which ensures fully compatibility and comparability among firms operating in different countries.

The sampling procedure has been the following. As a starting point, we ran a preliminary analysis on the annual reports provided by all companies listed in the five largest European countries: United Kingdom, Germany, France, Italy, and Spain.[1] First, in order for the firms to be included in the sample, descriptions and data about intangible assets had to enable the identification of the value of knowledge assets only. Second, a clear distinction between 'internally-generated intangible assets' and 'externally-generated intangible assets' had to be provided. This selection procedure yielded a total of 322 companies for the final analysis. We analyzed five consecutive annual reports (2008-2012) for each of the companies in the sample. The final dataset consists of 1,181 firm-year observations.

Finally, all monetary variables were homogenized by converting all values in the same currency (Euro), using the official exchange rate at the end of the accounting period, and applying a deflator using 2008 as year of reference.

Dependent Variable

We investigated the effect of inbound and outbound flows of knowledge on firm performance, measured in terms of sales growth. As shown in table 1, we measured sales growth (GROWTH), as the difference of the logarithms of sales in two consecutive years, an established indicator in several firm-growth studies (Coad, 2010).

Explanatory Variables

The key object of interest is firms' openness in terms of inward and outward flows of technological knowledge. We operationalized these variables through an in depth analysis of figures in the annual report about the 'Intangible Assets' (Denicolai *et al.*, 2014). The content of these data and the rules according to which they are estimated and registered are defined by the International Accounting Standard (IAS 38). The inbound knowledge flows ratios (degrees of openness) is operationalized by taking the net book value of externally-generated knowledge assets - at the balance sheet date - divided by the annual turnover. Similarly, our

[1]These economies count for the 71% of the European Union GDP (Eurostat, 2013), whilst the companies listed in these five countries count for the 81.8% of total market capitalization in whole EU (World Bank, 2014).

measure of outbound flows (OUT) is calculated by taking the net book value of knowledge assets disposal - at the balance sheet date - divided by the annual turnover. The potential synergy (positive or negative) between IN and OUT open innovation activities (OI) is investigated through the analysis of the interaction between these two terms (IN*OUT). We also include some control variables: firm size in terms of employees (SIZE), R&D intensity (RD), and total value of knowledge assets (KNOW). The latter is a stock reported in the balance sheet, different from IN and OUT which are flows disclosed in the income statement. Furthermore, we introduce year dummies to control for any unobserved contingent 'year effect'.

[Insert Table 1 about here]

Descriptive Statistics and Correlations

Table 2 reports descriptive statistics and Pearson correlation coefficients for the variables of the econometric model. The correlations between the explanatory variables are small, so the likelihood of multicollinearity issues in the regression analysis is low.

[Insert Tables2 about here]

Table 3 presents the distribution of the sample in terms of firm size (number of employees): large firm are predominant as expected considering the pool of listed companies, though the portion of SMEs is anyway significant and equal to 24.9%. The wide range in terms of firm size allows to investigate open innovation dynamics in organizations owning different portfolios of resources: from small business to giant multinational companies[2].

[Insert Table 3 about here]

RESULTS

Table 4 reports the outcomes of the estimation of fixed effects panel data regressions. We first estimate the model including the control variables only (G1). R&D intensity (RD)

[2] See Appendix 1 for further information about sample distribution in terms of industry and country.

positively affects firm growth: this evidence is consistent with that offered by the mainstream literature (e.g. Del Monte *et al.*, 2003; Hoffman *et al.*, 1998; Wakelin, 2001). Findings also highlight that firm size (SIZE) negatively influences firm growth. Small firms typically have higher growth prospects than large organizations, as highlighted by recent studies (Coad *et al.*, 2012; Neumark *et al.*, 2011). Knowledge stock (KNOW) is not significant.

Model G2 investigates the impact of Inbound Innovation (IN) on firm growth. The coefficient of IN is positive (+0.526) and statistically significant ($p < 0.10$). We also tested a non linear relationship in Model G3, as suggested by Laursen and Salter (2006): both coefficients are significant ($p < 0.05$). IN remains positive (+1,322), while the squared term (IN2) is negative (-2.096). This result suggests an inverse U-shaped curve. However, 99% of the observations shows a IN openness lower than the one corresponding to the top of the function (maximum at IN=32.2%), indicating that the decreasing part of the curve is substantially out of the variable range. Hence, we find support for Hypothesis 1 and confirm than inbound innovation fosters firm growth, but through diminishing returns.

We, then, extend the study by adding the effect of outbound innovation (OUT) in Model G4. The coefficient of OUT is not significant. Thus, Hypothesis 2 is rejected. Our findings show that outbound innovation is not positively associated with firms' sales growth.

Models G5-G8 examine the interplay of inbound and outbound open innovation. First, Model G5 investigates whether IN is moderated by OUT – and *viceversa* – in affecting firm growth. IN retains its significance while the coefficient of OI - which expresses the interaction between the two forms of openness - is positive (+9.372) and highly significant ($p < 0.01$), thus suggesting a synergic interplay of the two variables. This finding supports our Hypothesis 3. OUT is again non significant.

Consistently with Model G3, the Model G6 examines whether the moderating effect of outbound flows (OI) holds when the impact of IN on firm growth is studied through a curvilinear function. Findings are intriguing: the two coefficients OI and OI2 - the latter calculated as IN2*OUT –are both significant, respectively negatively (-21.28) and positively (+243.1). Hagedoorn and Wang (2012) used a similar econometric procedure to examine the interaction of internal and external R&D strategies, getting comparable coefficients.. Hagedoorn and Wang (2012) showed that they are complementary at higher levels of in-house R&D investments, whereas at lower levels,, internal and external R&D are substitutive.. Catozzella and Vivarelli(2014) further support these dynamics .

To summarise, our results support that inbound and outbound flows of knowledge are substitute at low levels of IN openness, while they are complementary at high levels of IN

openness. Since the above-mentioned threshold is significantly higher than the IN mean value reported in our study, we surmise that, normally, firms struggle to pursue inbound and outbound innovation. Nevertheless, in case of high levels of open innovation, the situation is inverted and synergies among inward and outward flows may occur.

Hypothesis 3 is thus supported but in a revised form: inbound and outbound flows of knowledge have a synergic positive effect on firm performance, but only in presence of sufficient investment in such activities. Coefficients in table 4 (model G6) define a threshold of inbound intensity (when IN=0.0874) after which the investment to increase OUT openness further enhances the positive effect of inbound openness (complementary activities).

Model G7-G8 confirms that the results on OI are also stable when removing IN and OUT.

[Insert Table 4]

CONCLUSIONS

Our study investigated the impact of both inward and outward flows of knowledge on firm growth. In particular, we focused on market transactions, namely technology acquisition and commercialization. Our empirical evidence uncovers conditions by which inbound and outbound forms of openness are substitute or complementary activities. Synergies among inward and outward flows of knowledge that foster firm growth occur only at high levels of inbound openness. Our study offers several contributions. Complementing recent literature that has analyzed the potential complementarity between inbound and outbound knowledge flows (e.g. Cassiman and Valentini, 2015),[3] we posit the idea that companies have to be well equipped to pursue high levels of open innovation and achieve synergies among their inbound and outbound activities. Our findings also have managerial implications, since they provide useful insights to inform decisions on investment in open innovation. The successful pursuit of both inbound and outbound initiatives seems to occur only when a company is really committed and is ready to invest significant resources in that direction.

This study has of course some limitations as well. First, we focused on knowledge assets that are codified and reported into accounting statements, neglecting other types of knowledge, such as managerial or marketing knowledge, as well as the whole tacit dimension. Second, we acknowledge that at this stage we only establish conditional

[3] Compared to their study, this paper (a) analyzes a panel and not a cross-section, (b) has a more fine-grained measure of Open Innovation, (c) analyzes different measures of performance and along different econometric specifications.

correlations that obviously do not imply causality. Nevertheless, we think that our findings shed a new light on the field and suggest promising avenues for future research.

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TABLES AND FIGURES

Table 1. Description of the key variables

Variable		Description
GROWTH	FirmGrowth (dependent variable, models 'a')	LN (Sales $_{t+1}$) - LN (Sales $_{t}$)
SIZE	Firm size in terms of employees	LN (Employees$_t$)
KNOW	Value of Total Knowledge Assets (stock)	LN (Total Knowledge Assets Stock $_t$)
RD	R&D intensity	R&D expenditure$_t$/ Sales$_t$
IN	Inbound flows of knowledge ratio (e.g. patent acquisition)	Net book value of Externally Generated Knowledge Assets $_t$/ Sales$_t$
OUT	Outbound flows of knowledge ratio (e.g. patent sold or expired)	Net book value of Knowledge Assets Disposal$_t$ / Sales$_t$
OI	Open Innovation effect, as the synergic effect between 'Inbound' and 'Outbound' flows of knowledge	IN * OUT

Table 2. Descriptive and Correlations

	Mean	Std. D.	GROWTH	SIZE	KNOW	RD	IN	OUT
GROWTH	0.0160	0.2290	1					
SIZE	7.1934	2.2151	-0.0366	1				
KNOW	15.8169	3.1557	-0.0429	**0.6321**	1			
RD	0.3765	3.1174	0.0344	**-0.2092**	**-0.0569**	1		
IN	0.0117	0.0378	0.0045	**-0.1419**	**0.0857**	**0.0804**	1	
OUT	0.0088	0.0464	0.0180	**-0.1081**	-0.0128	0.0312	0.0223	1

Bold values indicate correlation significant at .05 level.

Table 3. Descriptive and Correlations

Firm Size	Employees	Distribution
Small	<50	5.8%
Medium	50 - 250	19.1%
Large	250 - 2,500	37.1%
Very Large	> 2,500	38.0%

Table 4. Regression analysis (a): The impact of Inbound and Outbound flows of knowledge on Firm Growth (fixed effects panel model)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DV=GROWTH	Model G1	Model G2	Model G3	Model G4	Model G5	Model G6	Model G7	Model G8
y9	0.140***	0.141***	0.142***	0.141***	0.141***	0.144***	0.140***	0.142***
	(0.0162)	(0.0162)	(0.0162)	(0.0163)	(0.0163)	(0.0163)	(0.0162)	(0.0162)
y10	0.120***	0.119***	0.121***	0.121***	0.119***	0.122***	0.119***	0.121***
	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)	(0.0177)
y11	0.0628***	0.0632***	0.0644***	0.0646***	0.0636***	0.0661***	0.0635***	0.0644***
	(0.0187)	(0.0185)	(0.0184)	(0.0184)	(0.0186)	(0.0185)	(0.0187)	(0.0187)
SIZE	-0.276***	-0.279***	-0.283***	-0.283***	-0.283***	-0.284***	-0.279***	-0.278***
	(0.0551)	(0.0551)	(0.0556)	(0.0557)	(0.0554)	(0.0559)	(0.0552)	(0.0552)
KNOW	-0.00517	-0.00576	-0.00622	-0.00612	-0.00591	-0.00620	-0.00520	-0.00522
	(0.00589)	(0.00588)	(0.00586)	(0.00588)	(0.00590)	(0.00589)	(0.00589)	(0.00590)
RD	0.0147***	0.0149***	0.0149***	0.0149***	0.0154***	0.0166***	0.0152***	0.0164***
	(0.00291)	(0.00301)	(0.00297)	(0.00299)	(0.00337)	(0.00438)	(0.00321)	(0.00426)
IN		0.526*	1.322**	1.324**	0.504*	1.310**		
		(0.296)	(0.515)	(0.515)	(0.291)	(0.526)		
IN2			-2.052**	-2.053**		-2.245**		
			(0.891)	(0.891)		(0.906)		
OUT				0.0770	-0.117	0.00793		
				(0.178)	(0.129)	(0.123)		
OI					9.372***	-21.28*	8.544***	-18.25*
					(3.054)	(11.70)	(3.139)	(10.68)
OI2						243.1***		226.6***
						(89.27)		(84.65)
Constant	1.996***	2.023***	2.052***	2.048***	2.050***	2.057***	2.017***	2.006***
	(0.402)	(0.402)	(0.404)	(0.405)	(0.405)	(0.408)	(0.403)	(0.403)
Observations	1,181	1,181	1,181	1,181	1,181	1,181	1,181	1,181
R-squared	0.173	0.178	0.182	0.182	0.181	0.188	0.177	0.180
Number of id	322	322	322	322	322	322	322	322

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1