TRANSLATIONAL TWISTS AND TURNS: SCIENCE AS A SOCIO-ECONOMIC ENDEAVOR

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From inception to exploitation: research trails in biotechnology start-ups

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Abstract

The pathway of an idea generated in academic and exploited in industry is complex. For start-ups located in Science Parks, the skills and knowledge acquired during previous research needs to be successfully exploited. In this study we collect patent and publication data on single-site start-ups and their founders, located in the Leiden Bioscience Park. Using these data we examine in detail the contributions of the founders' host universities, other firms located in the Science Park, and the internationalism characteristics of the firms' collaborations pre- and post-incorporation. We link the patent applications of the firms to the firm founders' publication through the literature cited by the patent applications. We find that the sample set of firms incorporate, in addition to their own continued streams, new streams of academic research with their technological output with publishing and patenting partners varying according to their proximity to the park.

Introduction

From inception to exploitation, the knowledge pathway follows a convoluted route. For firms located on Science Parks, the transformation from exploratory research to exploited artefacts is an end-goal of the firm and, by extension, the host Science Park. However, this process begins before firm incorporation and before locating on a Science Park. Without this transformation, all the economic, technological, scientific and social benefits a Science Park purportedly offers are moot. It is for this reason that our study aims to examine, in detail, the knowledge capture and transformation mechanisms that are present from the start, based on the initial carrier of this knowledge, the firm founder, in the environment of the firm, the Science Park.

Conceptual framework

Science Parks

Science parks provide an environment for large firms to develop relationships with small firms; promote formal and informal links between firms, universities and other small labs (Siegel, et al., 2003). They provide a contact space between applied and basic science (Quintas, et al., 1992); promote foreign investment transition to a knowledge-based economy (Koh, et al., 2005). They provide technological development and renewal on a regional or national basis (Phillimore, 1999). Firms choosing to locate on Science Parks do so based on combinations of neo-classical theory (transport, labour costs, agglomeration economies) or behavioural aspects (the Science Park acts as mediator, gatekeepers, add to reputation) or structuralist theories (Science Parks create an innovation milieu) (Westhead & Batstone, 1998).

Knowledge capture

Access to resources, assets and capabilities include not only the contextual and network benefits of a Science Park but also the skills and knowledge of the personnel of the firm. These begin with, and is largely shaped by, the firm founder (Bozeman, et al., 2001). The decision to exploit the base knowledge stock is complex, and the process of becoming an "entrepreneurial scientist" (Oliver, 2004) is difficult. The process of recognising and incorporating new knowledge is that of absorptive capacity (Cohen & Levinthal, 1990). With a mind to incentives, the scientist employs a number of strategic decisions (Horlings & Gurney, 2012), guided by the perception of the trade-off between field crowdedness, problem difficulty and potential reputational gains (Zuckerman & Cole, 1994). After the firm has been incorporated, the firm founder takes into account new stakeholders and the need to balance exploiting current knowledge developing new knowledge.

Aim

We have previously developed and extended methodological tools that describe the search strategies, and exploitation activities, of researchers (Gurney, et al., 2012; Horlings & Gurney, 2012). Based on these, we aim to examine:

– The cognitive routes and developments of an idea generated in academia and exploited in the setting of a Science Park.

We do so by investigating:

(a) The links between firm founder(s) knowledge stocks and their technological output including the scientific and technological links to firms in the Science Park, and HEIs and public research institutes in close geographic proximity to the Science Park;

(b) The continuity of research conducted by the firm founder(s) – prior to firm incorporation and at certain periods after incorporation;
(c) The composition of academic and industrial collaborations of the firm and firm founder(s) including the regionalism/internationalism of collaborators;

Method

Science Park and firm selection

Leiden BioScience Park is a biomedical cluster in The Netherlands and the subject of our analysis. Nearby HEIs include Leiden University (and their Medical Centre), The Hogeschool Leiden (Applied Sciences) and other knowledge institutions such as TNO and Top Institute Pharma. There is a park administration partnered with a facilities and strategy manager. The firms were selected on 3 primary criteria: firm formation was within the last 10 years; the firm was founded by a university or knowledge institute researcher; and lastly, the firm is from the life sciences and health sector. Following these criteria, we collected full patent and publication data for 9 firms.

Patents and publications

For patent data we use the PatSTAT database prepared and developed by the EPO. All patent applications of the firm or firm founder(s) listed as an applicant, or firm founder(s) listed as inventor, were collected. We used Thomson Reuter's Web of Science (WoS), supplemented with CV data from the scientists involved to collect all publications of the firm founder(s) (up to June 2012).

These base data were parsed using SAINT (2009) and managed in a relational database. Further data were collected from the patents, specifically:

(1) In-text non-patent literature references (IT-NPLRs) – citations to publications visible in the body of the patent.
(2) Bibliographic NPLRs (B-NPLRs).

Both NPLR sets were parsed and, as far as possible, their WoS publication equivalents retrieved. The verified documents were then parsed and processed separately for a per-firm analysis and collectively for a group analysis. The addresses found within the publication and patent application data were coded for country of origin and type of entity.

Patent and publication visualisation and analysis

Publications were clustered by their shared combinations of title words and cited (van den Besselaar & Heimeriks, 2006). The degree of similarity was calculated using the Jaccard similarity coefficient. Clusters of publications were automatically assigned by their degree centrality and relative

weights of edges between nodes (Blondel, et al., 2008). The NPLR of the patent applications were included in the clustering of the publications.

Using NPLRs we linked the publications to the patent applications. Even if the patent applications do not directly cite the work of the founder(s), the NPLR that are cited cluster within the founder(s) corpus, inferring a link to the founder(s) areas of expertise. As a result, an indication of the degree of knowledge transfer and absorptive capacity from the research practices and results of the founder(s) to their technological output can be observed and elucidated.

Results

Scientific and technological output relevance

In Table 1, the publishing propensity and diversity differs by firm founder. The continuity of research involving the founder is low for all firms except one (Firm 2). The number of active streams with NPLRs co-clustering within the stream indicates a link to the founder(s) publication corpora relevant at the start of the firm.

Table 1. Founder(s) publishing research streams.

	Number of Streams					
FIRM ID	**Total**	**Active at incorporation**	**New after incorporation**	**Active 1 year after incorporation**	**Active 3 years after incorporation**	**Active at incorporation with NPLR**
1	9	5	0	5	3	5
2	20	10	2	9	7	7
3	7	1	1	1	0	0
4	7	3	1	3	3	3
5	14	3	1	2	0	0
6	4	0	2	0	0	0
7	2	1	1	1	1	1
8	3	0	0	0	0	0
9	10	1	2	1	1	0

Academic and industrial collaborations

Table 2a shows that for most of the firms with active research streams at incorporation, the authors primarily come from academia. Firm 3 and 9 have a large portion of their authors coming from industry, with Firm 9 showing a varied mix of academic and/or industrial authors.

Table 2a. Academic and industrial collaboration composition of founder(s) publishing research streams.

	Percentage author composition of papers in research streams active at incorporation				
FIRM ID	**Academic**	**Predominantly Academic**	**Academic and Industrial**	**Predominantly Industrial**	**Industrial**
1	89	1	7	1	2
2	98	1	1	0	0
3	67	0	0	33	0
4	99	0	1	0	0
5	93	0	7	0	0
6	-	-	-	-	-
7	82	9	9	0	0
8	-	-	-	-	-
9	30	10	40	20	0

Table 2b presents the assignee composition of the patenting efforts of all the firms. Firms 3, 7 and 8 have industrial assignees exclusively, and Firm 9 has a vast majority of industrial assignees (94%). Firm 1 patents almost equally with academic and industrial assignees, whilst the rest of the firms tend to academic assignees.

Table 2b. Academic and industrial collaboration composition of patent assignees pre- and post-incorporation.

		Number of patent applications and count of assignee origin pre/post inc.				
		Academic	**Predominantly Academic**	**Academic and Industrial**	**Predominantly Industrial**	**Industrial**
Firm ID	**Total**	**Pre/Post**	**Pre/Post**	**Pre/Post**	**Pre/Post**	**Pre/Post**
1	67	16/14	0/0	19/0	3/2	9/4
2	13	7/5	0/0	0/0	1/0	0/0
3	6	0/0	0/0	0/0	0/0	4/2
4	16	8/3	0/0	0/0	0/0	2/3
5	7	-/0	-/0	-/0	-/0	-/7
6	30	-/0	-/0	-/9	-/1	-/20
7	10	0/0	0/0	0/0	0/0	2/8
8	9	0/-	0/-	0/-	0/-	9/-
9	45	3/0	0/0	0/0	0/0	34/8

Local, regional and international collaborations

Tables 3a and 3b present academic collaborations of all the firms in our set. Table 3a indicates the geographic distribution of academic collaborators in the publishing streams of the firms. All the

firms publish with at least one Dutch academic address. Firm 7 publishes exclusively with Dutch academic partners and Firms 1 and 8 publish extensively with only Dutch partners. Firm 5 is the more international wherein it publishes almost exclusively with Dutch and RoW academic partners.

Table 3a. International composition of ***academic collaborators*** *of founder(s) publishing research streams.*

	Percentage composition of academic collaborators in research streams active at incorporation			
FIRM ID	**NL only**	**NL & EU**	**NL & RoW**	**NL & EU & RoW**
1	71.3	14.3	6.4	8.1
2	36.2	21.5	36.9	5.5
3	50	16.7	33.3	0
4	31.7	57.1	4.1	7.2
5	0	0	95.4	4.6
6	-	-	-	-
7	100	0	0	0
8	-	-	-	-
9	80	0	10	10

Links with Leiden University are considered integral to the Science Park, and are reported as such by all the firms in the set. Table Results 3b shows the composition of academic collaborations with Leiden University, other Dutch universities and Dutch knowledge institutes.

Table 3b. Composition of ***Dutch academic collaborators*** *of founder(s).*

	Percentage presence of Leiden University, other NL universities or knowledge institutes(KI)											
	Active at incorporation			**New after incorporation**			**Active 1 year after incorporation**			**Active in 2011**		
FIRM ID	**Leiden**	**Other Uni**	**KI**	**Leiden**	**Other Uni**	**KI**	**Leiden**	**Other Uni**	**KI**	**Leiden**	**Other Uni**	**KI**
1	81.3	7.3	3.8	-	-	-	81.3	7.3	3.8	75.9	12	0
2	22	23.5	11.2	100	100	0	22	23.5	3.9	23.1	22.2	3.9
3	0	20	80	0	0	0		20	80	-	-	-
4	95.5	2.7	2.7	66.6	16.6	0	95.5	27	2.7	86.5	2.7	2.7
5	0	0	0	0	0	0	0	0	0	-	-	-
6	-	-	-	75	62.5	0	-	-	-	75	25	0
7	76.9	7.7	7.7	62.5	18.7	0	76.9	7.7	7.7	69.7	15	7.7
8	-	-	-	-	-	-	-	-	-	-	-	-
9	90.9	9.1	0	55.7	27.1	20	90.9	9.1	0	67.4	21.1	20

For firms with active research streams at incorporation, the vast majority of academic collaborations are with Leiden University. This is to be expected as many of the firm founder(s) maintain active faculty positions at Leiden. There are also large numbers of collaborations with other Dutch universities. For all firms, the vast majority of academic patent collaborators of the firms are from The Netherlands except for Firm 2 who collaborates with RoW academic partners on just under a third of their pre-incorporation patent applications.

Table 4 shows the international composition of the industrial assignees of the patent applications of the firms, pre- and post-incorporation. Half the firms began to develop their patent stock prior to incorporation, and 3 of the firms developed over 80% of their knowledge stock after incorporation. All but 3 of the firms have only Dutch and/or EU industrial assignees. However, none of these collaborations are with firms located in the Science Park. The patent stocks of the 3 firms with RoW industrial partners were developed prior to incorporation. Significantly, there are no other firms from the Science Park listed as assignees in any of the 9 firms' patent applications.

Table 4. International composition of ***industrial patent assignees****.*

	Industrial co-assignees as a percentage of total assignees pre- and post-incorporation			
	NL only	NL & EU	NL & RoW	NL & EU & RoW
Firm ID	Pre/Post	Pre/Post	Pre/Post	Pre/Post
1	62.2/13.5	18.9/2.7	2.7/0	0/0
2	0/-	0/-	0/-	100/-
3	0/28.6	28.6/0	42.9/0	0/0
4	40/40	0/20	0/0	0/0
5[a]	-/100	-/0	-/0	-/0
6[a]	-/100	-/0	-/0	-/0
7	0/80	20/0	0/0	0/0
8	5.3/52.6	42.1/0	0/0	0/0
9	81/19	0/0	0/0	0/0

a All applications are with founder firm as only industrial assignee.

Conclusions and discussion

The firm founder begins, in most cases, as an academic researcher. Much of the scientific and technical expertise developed previously was still employed by the firms at the end date of our data collection. Most firms struck balances between explorative activities and exploitative activities in punctuated equilibrium, a reported process described by Gupta et al. (2006).

The alma mater universities of the founders played a large role in the initial IP development, but after incorporation industrial partners soon supplant the universities. The share of international

collaborators in the academic output of the founders is high to begin with for most of the firms. The number of international *industrial* collaborations varies across the firms, both in patenting and publishing.

After incorporation, only firms with founders still active at the university continue a high level of international academic collaboration. For firm founders who are not active faculty, publishing activities become increasingly local, mostly with their alma mater and increasingly with Leiden University. Most of the founders interviewed found that customers for the products and services they provide are not local or even regional. Rather they are mostly from the EU or further. This would suggest that whilst there may not be a local market for their products and services, the research conducted towards developing the products and services is strongly helped by the local education and industrial sectors.

Our sample size is restricted by our selection criteria, and the diversity of the firms is too high to conduct statistical comparisons but we believe that the level of detail in our study outweighs the restrictive selection criteria and adds a new dimension to future studies on academic entrepreneurs and Science Parks. Our study can provide insight in further studies for policymakers as to the historical development and level of collaboration between firms located on Science Parks and the internationalism of academic or industrial collaborations.

Our results seem to suggest that the close association of start-ups with the local university and with national industrial partners lead to a more innovative firm. A better matching process of the products and services offered by the firms to local or national customers could boost regional development through better identification of natural complementarities between research conducted in firms and with potential customers.

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