4 R&D OFFSHORING AND THE PRODUCTIVITY GROWTH OF EUROPEAN REGIONS

Authors:

Davide Castellani* (Centro Studi Luca d'Agliano, LdA, Italy, participant no.9)

Fabio Pieri (Department of Economics, Finance and Statistics, University of Perugia)

Abstract: The recent increase in R&D offshoring have raised fears that knowledge and competitiveness in advanced countries may be at risk of 'hollowing out'. At the same time, economic research has stressed that this process is also likely to allow some reverse technology transfer and foster growth at home. This paper addresses this issue by investigating the extent to which R&D offshoring is associated with productivity dynamics of European (NUTS2) regions. In particular, we explore whether R&D investments abroad have a different impact from those in manufacturing and other business activities. We find that offshoring regions have higher productivity growth, but this positive effect fades down with the number of investment projects carried out abroad. However, a large and positive correlation emerge between the extent of R&D offshoring and the home region productivity growth, supporting the idea that carrying out R&D abroad strengthen European competitiveness.

Key words: Regional Productivity, Europe, Offshoring of R&D and Production

*Corresponding author: Department of Economics, Finance and Statistics, Via A. Pascoli, 20, 06123 Perugia. Tel. 075 585 5060, email address: davide.castellani@unipg.it.

4.1 Introduction

Research and Development (R&D), together with other core business activities, is usually centralized at the firms' headquarters in the home country (Patel and Pavitt, 1991; Narula, 2002; Belderbos, Leten, and Suzuki, 2010), but in the last decades research has documented an increase in the internationalization of R&D and inventive activity (Guellec and van Pottelsberghe de la Potterie, 2001; Picci, 2010), which was at first mainly motivated by the need to better exploit existing home-based advantages (i.e. by adapting existing products to foreign markets needs), while more recently the need to source complementary assets, talents and competences abroad also became an important motive (Cantwell, 1995; Kuemmerle, 1999; Patel and Vega, 1999; von Zedtwitz and Gassmann, 2002; Le Bas and Sierra, 2002; Narula and Zanfei, 2005; Manning, Massini, and Lewin, 2008; Dunning and Lundan, 2009; Ambos and Ambos, 2011). This off-shoring of R&D activities11 is part of the broader emerging phenomenon of Global Innovation Networks (GINs), where domestic and foreign R&D labs (as well as production and marketing departments) of multinational and non-multinational firms interact within and across firms boundaries for the global generation and diffusion of innovation (Ernst, 2002, 2011; Barnard and Chaminade, 2011). The trend towards locating R&D activities abroad have raised concerns that the knowledge base of advanced countries may be 'hollowed out', worsening their relative international competitiveness2 . At the same time, economic research have highlighted the potential benefits of offshoring R&D in terms of reverse technology transfer and increased competitiveness at home. In this work, we address this issue by assessing – for the first time – the extent to which the productivity of European regions is associated with the offshoring of R&D activities by domestic multinational enterprises (MNEs) based in 265 NUTS 2 regions in the EU3 . The focus on regional productivity allows us to capture not only the direct effect of R&D offshoring on firms' competitiveness, but also the effect through the growth in size of offshoring firms (i.e. through market shares reallocation) and the indirect effect via increase/decrease in local firms' productivity and propensity to enter/exit the market ('spillover' effect)4 . The effect of R&D offshoring on regional productivity is particularly relevant in the European Union (EU) where outward FDIs account for almost 4% of the EU GDP, but with very differentiated patterns across countries5 and where regional competitiveness and social and economic cohesion have been crucial concerns for policy makers6.

[1] [R&D] Offshoring is defined as the location or transfer of [R&D] activities abroad. It can be done internally by moving services from a parent company to its foreign affiliates (sometimes referred to as 'captive' or 'in-house' offshoring), or to third (unrelated) parties (referred to as international or offshore outsourcing) UNCTAD (2006). Due to data limitations, the analysis carried out in this work will refer to 'captive' R&D offshoring only.

[2] See, for example, Lieberman (2004) for the US, and Kirkegaard (2005) or Pro Inno Europe (2007) for Europe.

[3] NUTS is an acronym for Nomenclature of Units for Territorial Statistics which indicates a hierarchical classification of administrative areas used by the European statistical office (Eurostat). NUTS levels (1-3) indicate different degrees of aggregation.

[4] Unfortunately, due to the lack of disaggregated data we cannot evaluate the relative contribution of these different channels.

[5] For example outward FDIs, as a share of GDP, go from values close to zero in most New Member States, to around 1% in countries such as Italy and Greece and more than 5% in the UK, France and Spain.

[6] As a matter of fact, 35% of the EU budget for the period 2007-2013 has been allocated to promote social and economic cohesion among the regions of its member states.

In order to investigate whether offshoring of R&D affects regional productivity, we gather data on international investment projects, from which we are able to build unique measures of outward (and inward, which will be used as controls) foreign direct investment (FDI) in R&D, as well as in manufacturing and other business activities, at the regional level (NUTS 2), for the countries of the European Union (EU-27). We then estimate regressions of productivity growth as a function of the lagged number of international R&D projects, controlling for a measure of inward FDIs, as well as other regional characteristics and country fixed effects. We find that offshoring regions have higher productivity growth and a positive correlation emerges between the number of R&D projects abroad and the home region productivity. Inward investments are also positively associated with regional productivity growth, but only above a certain threshold.

The rest of the paper is organized as follows: Section 2 presents the related literature; Section 3 provides details on the characteristics of the data and focuses on how the main variables of interest have been measured and constructed, while Section 4 illustrates the econometric specification and results. Section 5 concludes the paper.

4.2 Related literature

4.2.1 Theory

Aggregate productivity dynamics can be explained by changes in productivity at the level of the firm (the within-component of productivity growth) and by reallocation of resources across incumbents and through entry and exit (the between-component) (Bartelsman and Doms, 2000). The literature on the effects of R&D offshoring has focussed on the within-component, and has provided already a certain amount of empirical evidence at the firm-level (see section 2.2). R&D offshoring increases firms' productivity by augmenting their stock of knowledge. The growing need for enhanced innovation capability is leading firms to expand technology sourcing and interaction with different and geographically dispersed actors (Narula and Zanfei, 2005). On the one hand, R&D labs abroad are needed to be able to quickly and effectively adapt products to the need and specificities of local markets. Eventually, innovation developed for the local markets can be decontextualized and become part of the knowledge base of the multinational firms and exploited elsewhere Zanfei (2000). On the other hand, R&D offshoring is needed to gain access to crucial inputs such as knowledge and technology complementary to those developed at home, as well as and highly qualified and/or lower cost R&D personnel (Manning, Massini, and Lewin, 2008; Cantwell, 1995; Chung and Yeaple, 2008; Puga and Trefler, 2010). However, R&D offshoring does not necessarily imply that knowledge and productivity at home increase. First, offshored labs need to be able to actually extract knowledge from foreign locations, and this may need time and investments in order to establish relations with actors in the host innovation system (Narula and Michel, 2009). Second, the firm must be able to manage reverse knowledge transfers (from the offshored labs back to the headquarters and the rest of the company), which may require the adoption of sophisticated mechanisms for the dissemination and integration of both explicit and tacit knowledge (Gupta and Govindarajan, 2000).

One less explored channel through which R&D offshoring can affect aggregate productivity in the home region is through the reallocation of market shares. As a matter of fact, theoretical and empirical work tend to agree that offshoring allows to sell more, thanks to the fact that offshoring

firms can charge lower prices or adapt products to local needs (Grossman and Rossi-Hansberg, 2008; Barba Navaretti, Castellani, and Disdier, 2010). Provided that offshoring firms are the relatively more productive ones (Helpman, Melitz, and Yeaple, 2004), regional productivity would increase even in the extreme case where no firm increases its own productivity, simply because offshoring firms increase their market share.

R&D offshoring may also have indirect effects on the productivity, size and entry/exit of other firms in the home region. This mechanism is similar to the spillover effects which has been analysed at length with reference to inward FDI and foreign-owned firms (Castellani and Zanfei, 2006). By opening R&D labs abroad, multinational firms may close down activities in the home country, thus disrupting linkages with local firms and institutions. This shrinks the activities of local firms, which may ultimately be forced to exit. Alternatively, if R&D offshoring enables some reverse knowledge transfer, domestic counterparts may also benefit of some positive externalities, via labour mobility, imitation or interfirm linkages.

In sum, R&D offshoring affects home productivity through a variety of channels, and only some of them are observable at the level of individual firms. An aggregate perspective allows to evaluate the net effects of such different transmission channels. Furthermore, the effects of offshoring are most likely relatively confined in space and, thus, the regional level would more appropriate than the country level to capture them[7] . Admittedly, the drawback of this type of analysis is that we cannot pin it down to the various channels[8] .

4.2.2 Empirics

This paper relates to a number of other empirical studies available in the literature. As in Gambardella, Mariani, and Torrisi (2008) – and unlike the bulk of the works on the determinants of productivity differences among EU regions, which focus on the role of agglomeration economies, technology and human capital (e.g. Ciccone, 2002; Paci and Usai, 2000) – the productivity of European regions is explained by some measure of openness9.

Our work is also linked with studies investigating the effect of R&D offshoring on knowledge production at home. In this line of research, Criscuolo, Narula, and Verspagen (2005) and Criscuolo (2009) find evidence of reverse technology transfer for European firms using patent citation data, while Piscitello and Santangelo (2010) and D'Agostino, Laursen, and Santangelo (2010) support the hypothesis that patenting activity in OECD countries and regions benefit from offshored R&D

[7] First, the smaller the units of observation, the easier it would be to appreciate the direct effects of FDI, which may be more diluted in more aggregate data. Second, indirect effects may be enhanced by the geographic proximity, which can be important for transmitting knowledge as face-to-face communication (Audretsch and Feldman, 2004). Third, in the presence of transport costs, vertical linkages (which foster pecuniary and knowledge externalities) occur between closely-located suppliers and customers (Venables, 1996).

[8] Aggregating micro-level information would help us obtaining sharper answer (see Altomonte and Colantone, 2009). Unfortunately, this does not appear as a viable alternative at the moment since the available firm-level data comparable across countries (e.g. from Amadeus) provide a rather poor match with aggregate data (and for a few countries), but it is on the agenda for future research

[9] Gambardella, Mariani, and Torrisi (2008) measure regional openness as the share of hotels in total population and the share of the population which speaks a second language.

activities in Emerging economies (BRICKST). Using firm-level data, from the Spanish Technological Innovation Panel (Nieto and Rodriguez, 2011) find a positive relation between offshoring and innovation performance, with a greater effect on product than on process innovations and through captive offshoring than offshore outsourcing. Similar results have been reported from a survey on 158 EU companies. According to R&D managers of the interviewed firms companies have benefitted from R&D offshoring as far as i) the ability to choose successful R&D projects, ii) length of time it takes to commercialise an innovative idea, iii) the cost efficiency of product innovation processes or iv) the ability to learn about R&D conducted by other firms are considered (Pro Inno Europe, 2007).

Our study follows a also fruitful line of research on outward investments and productivity, which has taken mainly a firm-level perspective. Many studies in this field have provided evidence that investing abroad may foster output growth and further reinforce productivity of investing firms (Barba Navaretti, Castellani, and Disdier, 2010; Debaere, Lee, and Lee, 2010; Griffith, Harrison, and Reenen, 2006)

4.3 Data and variables

4.3.1 Data sources

We exploit an original database, which has been compiled recovering data from different sources. Data refer to European regions, at the NUTS 2 level: this level of analysis has been chosen for three main reasons. First of all, it is suitable for taking into account the within-country heterogeneity (in terms of labour productivity, foreign direct investments and the other observed and unobserved characteristics); second, it allows for comparable units across different countries; finally, more information is available on other regional characteristics at this level of disaggregation.10

4.3.2 Labour Productivity

The dependent variable is the labour productivity, which has been computed as the ratio of the regional gross valued added (at basic prices in millions of euro) obtained from the EU Regional Database developed and maintained by Eurostat11 , while data on employment at the regional level come from the European Regional Database, developed by Cambridge Econometrics (release 2006). Value added has been deflated using nationwide indexes, available in the Growth and Productivity Accounts database developed by EU KLEMS12 (releases 2008 and 2009). The last year for which information on value added are available in the Regio database is 2006. The time structure of our data imposes some constraints on the empirical analysis. In particular, regional productivity is observed only up to 2006, while information on foreign investments are available for the period 2003-2008. Thus, if we want to assess the econometric relationship between the latter and the former, we are left with four years of data: 2003, 2004, 2005 and 2006.

[10] SeeTable A.3 in the Appendix for the detailed list of regions, that have been considered in the econometric analysis.
[11] See the Eurostat web page http://epp.eurostat.ec.europa.eu/portal/page/portal/region cities/.
[12] See the web page of the EU KLEMS project at http://www.euklems.net/.

Figure 1 provides a graphical representations of the variables measuring the labour productivity in levels and growth at the NUTS 2 level. Labour productivity levels are clearly higher in the core regions of the EU-15, while decline in Southern European regions and reach minimum values in the regions of EU-12 countries. As for the growth rates, rather similar patterns are observed in regions belonging to the same country mainly in EU-12 countries, but also in Italy, France and Spain; while in Germany and UK productivity growth displays a remarkable within-country variability. In order to account for possible biases stemming from these country patterns in productivity growth, country dummies will introduced in our estimated equation.

Figure 1: Regional patterns of labour-productivity level and growth, 2003-2006 (average)

(a) Labour productivity (level)

(b) Labour productivity (growth)

4.3.3 Measures of offshoring

Data on offshoring have been recovered from fDi Markets, an online database maintained by fDi Intelligence —a specialist division of the Financial Times Ltd—, which monitors crossborder investments covering all sectors and countries worldwide. Relying on media sources and company data, fDi Markets collects detailed information on cross-border greenfield investments (available

since 2003)13 . fDi Markets data are based on the announcement of the investment and provides daily updated data. For each investment project, fDi Markets reports information on the investment (e.g., the leading industry sector of the investment), the home and host countries, and regions and cities involved, and the investing company (e.g., location, parent company). The database is used as the data source for FDI project information in UNCTAD's World Investment Report and in publications by the Economist Intelligence Unit. This source tracked 60,301 worldwide investments projects appeared on publicily available information sources in the period 2003-2008.

One of the limitations of the fDi Markets database is that it collects planned future investments. Some of these projects may not actually be realized or may be realized in a different form from the one originally announced. However, the database is regularly updated and projects which have not been completed are deleted from the database. In this regards, data on the projects related to the early years of the series should be more reliable than data regarding the last years of the series. We tackle this issue by dropping the last two years of data, so we use information on foreign investments from 2003 to 2006. Our measures of offshoring is then built as the number of outward investment projects from each region in each year of the period 2003-2006. We have also built measures of inward investments at the regional level, to control for possible confounding effects due to the fact that regions engaged in outward internationalization may also be those attracting more foreign multinationals. Admittedly, the count of investments projects may not be an accurate proxy of offshoring activity, since it does not weights investments for the value of the capital involved. However, the correlation coefficients (0.82 and 0.83), reported in Table 1, between the distribution of investments projects by EU countries and the actual distribution of FDI flows, as reported by UNCTAD, reassures us that data on investment projects are actually a good proxy for FDI flows. As expected, almost 90% of EU outward investments are made from EU-15 countries, while inward investments are split more evenly among EU-15 and EU-12 countries: United Kingdom, Germany and France result to be the leading countries both in terms of inward and outward FDIs in the period which goes from 2003 to 2006. As for the inward investments, Poland, Romania, Hungary, Czech Republic and Bulgaria show a good performance.14.

[13] A team of in-house analysts search daily for investment projects from various publicly available information sources, including, Financial Times newswires, nearly 9,000 media, over 1,000 industry organizations and investment agencies, data purchased from market research and publication companies. Each project identified is cross-referenced against multiple sources, and over 90% of projects are validated with company sources. More information at http://fdimarkets.com

[14] A careful inspection reveals that the number of projects overestimates inward FDIs to some New Member States, such as Poland, Romania, Bulgaria, Hungary and Czech Republic, probably due to the fact that these countries received a large number of relatively small-scale investments projects.

Table 1: *fDi Markets* projects vs. UNCTAD Flows, 2003-2006

	Outward			Inward	
Country	# proj.	flows	Country	# proj.	flows
Germany	22.2	11.7	United Kingdom	16.0	25.8
United Kingdom	20.3	16.3	France	9.2	15.2
France	13.8	17.6	Germany	8.3	8.1
Italy	6.3	5.7	Poland	6.5	3.0
Netherlands	5.9	13.7	Spain	6.2	7.2
Sweden	5.9	4.7	Romania	5.9	1.7
Austria	5.1	2.0	Hungary	5.4	1.4
Spain	4.6	11.7	Czech Republic	4.1	1.5
Finland	3.1	0.3	Bulgaria	4.1	1.1
Belgium	2.5	7.9	Ireland	4.1	-1.6
Denmark	1.9	1.4	Italy	3.9	5.9
Ireland	1.4	2.7	Sweden	3.2	3.4
Slovenia	1.1	0.1	Netherlands	3.1	5.1
Greece	0.9	0.4	Belgium	2.9	10.8
Latvia	0.9	0.0	Slovakia	2.6	0.8
Estonia	0.6	0.1	Lithuania	2.4	0.2
Portugal	0.5	1.2	Austria	2.2	1.9
Luxembourg	0.5	1.0	Denmark	1.9	1.2
Poland	0.5	0.7	Latvia	1.7	0.2
Czech Republic	0.5	0.1	Estonia	1.5	0.4
Hungary	0.4	0.4	Portugal	1.3	1.5
Lithuania	0.4	0.0	Greece	1.1	0.6
Cyprus	0.2	0.1	Finland	0.9	1.2
Romania	0.2	0.0	Slovenia	0.8	0.2
Slovakia	0.1	0.0	Luxembourg	0.4	2.7
Bulgaria	0.1	0.0	Cyprus	0.3	0.3
Malta	0	0.0	Malta	0.2	0.2
Total	100	100		100	100
Pearson corr. coefficient	0.82			0.83	

Unfortunately, official statistics on inward and outward investments at the regional level are not available, so we cannot benchmark fDi Markets data as this finer geographical level. However, a casual inspection based on Figure 3(a) highlight some expected patterns. In particular, they appear highly concentrated in a limited number of clustered regions within each country, including the regions around the major cities.

Exploiting the information on the main business activity involved in each of the international projects in the fDi Markets database, Figure 3(b) reports the share of R&D offshoring projects over the 2003-2008 period, while Figure 3(c) shows, for comparison, the share of outward investments in manufacturing activities. In line with the idea that R&D offshoring is still a limited, although increasing phenomenon, only a relatively small number of regions have some R&D offshoring activity, while manufacturing offshoring is much more pervasive and accounts for a larger share of total outward investments in each region, while R&D are usually a small portion.

Table 2 and A.1 provide some basic statistics for the variables later used in the econometric analysis. As concerns offshoring, Table 2 shows that, on average, from each region about 12.75 offshoring and 9.28 incoming projects per year have been recorded. However, the distribution of the number of projects is highly skewed: more than 25% of regions have no offshoring and more than 10% would not attract any inward investment. This skewness is even more evidence in the case of R&D offshoring, who is carried out by slightly more than 10% of the regions (the 90th percentile is equal to 1).

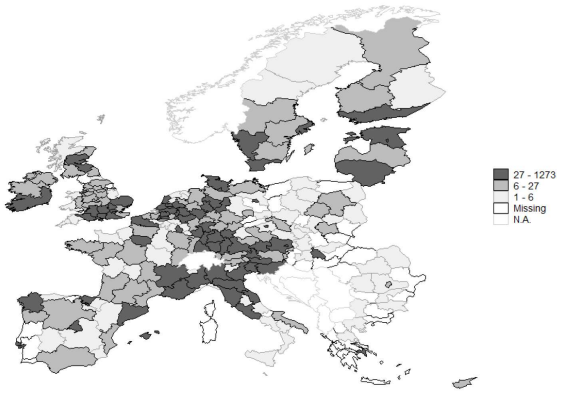
Table 2: Descriptive statistics, 2003-2005

variable	mean	p10	p25	p50	p90	p95	p99	max
OFF	12.75	0	0	2	30	55	129	404
OFF^{rd}	.54	0	0	0	1	2	12	29
$OFF^{manu/}$	3.14	0	0	1	8	13	33	90
INW	9.28	0	1	4	23	35	75	209

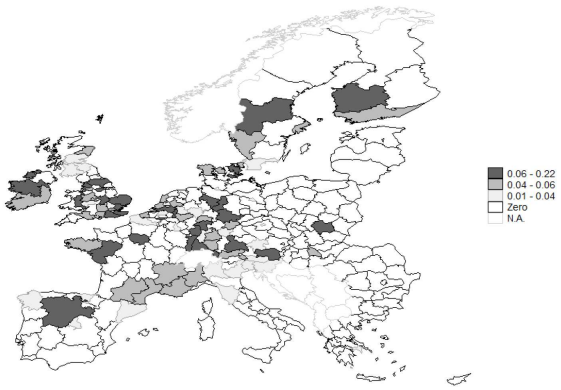
4.4 Econometric analysis

We estimate the effect of offshoring on the home region productivity growth, controlling for inward FDIs, the growth of capital-labour ratio, country-fixed effects and other regional characteristics. However, the skewness of the foreign investments variables induces us to model their effect as a combination of two dummy taking value equal to '0' for those observations (region/year) where no investments have taken place (OFF(d) and INW(d)) and two continuous variable (OFF(n) and INW(n)) taking the value equal to the number of investments in the case of non-zero investments, and '0' otherwise. This specification allows to distinguish the effect of a region being generally involved in offshoring, which is captured by the dummy variable, from the effect of the extent of offshoring, which is captured by the continuous variable.

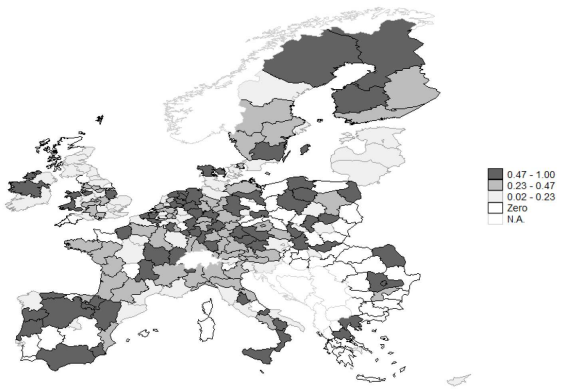
Figure 2: Regional distribution of offshoring projects, 2003-2006



(a) Total number of offshoring projects



(b) Share of R&D projects



(c) Share of manufacturing projects

The estimated equation then becomes:

$$\Delta y_{ij,t} = \alpha + \beta \Delta kl_{ij,t} + \Delta \mathbf{x_{ij,t}} \delta + \\ + \gamma^d OFF(d)_{ij,t-1} + \gamma^n OFF(d)_{ij,t-1} \cdot OFF(n)_{ij,t-1} + \\ + \lambda^d INW(d)_{ij,t-1} + \lambda^n INW(d)_{ij,t-1} \cdot INW(n)_{ij,t-1} + \\ + \eta_j + \tau_t + \Delta \epsilon_{ij,t}. \quad (1)$$

where klij,t indicates the (log of the) capital-labour ratio, xij,t is a vector of other regional characteristics, such as the level of human capital, the stock of technological capital, the regional industrial composition and the degree of concentration/diversification of the regional industry. We also include a vector of time effects, τt , to control for factors affecting all regions in the same way in a given year; while ηj is introduced in order to capture the country-specific trends in labour productivity. We make the hypothesis that foreign investments affect productivity with one-year lag15 .

We estimate Equation 1 by OLS, and the results are reported in the columns (1) and (2) of Table 3. In this case we are left with three pooled cross-sections of first-differenced equations: 2004-2003, 2005-2004 and 2006-2005 In this and the following regressions we report robust standard errors clustered by regions to control for the lack of independence of observations referring to the same region over time.

OLS estimates of equation 1 are reported in column (1) and (2) of Table 3. To be precise, in column (1) we estimate only the effect of the two dummies taking value 1 if a region has at least one outgoing or incoming investment project (respectively), while in column (2) we also estimate the effect of the number of investments. Results support that offshoring regions have a 0.6 percentage points higher productivity growth, while regions receiving inward investments appear to have lower productivity growth. Column (2) helps qualify this result: while the positive effect of offshoring is slightly decreasing in the number of investments, a higher number of incoming multinationals is associated with higher productivity growth. We performed a number of robustness checks, which we do not report here to save space16 . In particular, (i) we tested (and rejected) that offshoring may have contemporaneous effects on productivity growth, and that past offshoring may be endogenous with respect to current productivity growth ;(ii) we included controls for spatial dependence, as well as regional characteristics (in levels) –including population, a dummy for regions hosting the country capitals, the level of education, employment density, patenting activity, sectoral specialization– none of which change the results significantly.

[15] This specification can be though as deriving from one in levels, once accounted for regional fixed e*ff*ects by first-differencing. See (Castellani and Pieri, 2011) for more details.

[16] The reader can refer to (Castellani and Pieri, 2011) for details

Table 3: The effect of offshoring on EU regional productivity growth (OLS regressions)

	(1)	(2)	(3)	(4)
$OFF(d)_{t-1}$	0.0065***	0.0059**	0.0062***	0.0056**
	(0.0025)	(0.0024)	(0.0024)	(0.0024)
$OFF(n)_{t-1}$		-0.0001***	-0.0002***	-0.0002***
		(0.0000)	(0.0001)	(0.0001)
$OFF(n)^{rd}_{t-1}$			0.0014**	
			(0.0006)	
$OFF(n)^{man}_{t-1}$				0.0002
				(0.0002)
$INW(d)_{t-1}$	-0.0052**	-0.0055**	-0.0055**	-0.0057**
	(0.0023)	(0.0023)	(0.0023)	(0.0023)
$INW(n)_{t-1}$		0.0003***	0.0003***	0.0003***
		(0.0001)	(0.0001)	(0.0001)
$\Delta_{t,t-1}kl$	0.2234***	0.2416***	0.2429***	0.2412***
	(0.0809)	(0.0803)	(0.0803)	(0.0802)
Constant	0.0206***	0.0214***	0.0222***	0.0215***
	(0.0038)	(0.0036)	(0.0036)	(0.0036)
Country dummies	Yes	Yes	Yes	Yes
N. observations	769	769	769	769
N. regions	265	265	265	265

From Equation 1, it is possible to compute the threshold number of offshoring investments above which the overall effect is negative, and the number of inward investments above which the overall effect is positive. In particular, taking the partial derivative of labour productivity growth with respect OFF (d)

$$\frac{\partial \Delta y}{\partial OFF(d)} = \gamma^d + \gamma^n \cdot OFF(n). \tag{2}$$

The effect of offshoring will be positive as long as

$$OFF(n) > \frac{-\gamma^d}{\gamma^n}. \tag{3}$$

As for the effect of inward investments, the same calculation would yield that the effect is positive for

$$INW(n) > \frac{-\lambda^d}{\lambda^n}. \tag{4}$$

In particular, taking Specification (2) as a reference, with γ d = -0.0059 and γ n = 0.00013, the marginal effect of offhoring would be positive for a number of outgoing project smaller or equal to $\frac{0.00590}{0.00013}$ =44.6. From Table 2 we gather that this is between the 90th and 95th percentile, meaning that less than 10% of the regions actually experience a negative effect of offshoring on productivity growth. Conversely, the threshold for inward investments is $\frac{0.00550}{0.0003}$ =18.2, which is between the

75th and 90th percentile, suggesting that about one-quarter of regions benefit from incoming multinationals. The effect of R&D offshoring (as opposed to offshoring of manufacturing or other activites) on regional productivity is investigated augmenting the specification (1) with the number of outward investment in R&D and in manufacturing. In formal terms, our estimated equation takes the following form:

$$\begin{aligned}\Delta y_{ij,t} = \alpha + \beta \Delta kl_{ij,t} + \Delta \mathbf{x_{ij,t}} \delta + \\ + \gamma^d OFF(d)_{ij,t-1} + \gamma^n OFF(n)_{ij,t-1} + \gamma^{ba} OFF(n)^{ba}_{ij,t-1} \\ + \lambda^d INW(d)_{ij,t-1} + \lambda^n INW(n)_{ij,t-1} + \eta_j + \tau_t + \Delta \epsilon_{ij,t}. \quad (5)\end{aligned}$$

where ba denotes the business activity (i.e. R&D or manufacturing). Results reported in column (3)-(6) Table 3, show that R&D offshoring is associated with significantly higher productivity growth, while the effect of offshoring production is not different from the overall effect. It is worth mentioning that the magnitude of the effect of R&D offshoring is remarkable: our estimates suggest that comparing two regions that have the same degree of offshoring (and everything else constant), if we let one have an additional R&D project abroad in one year, this region would experience a rise in productivity growth by 0.14 percentage points the next year.

So far we have considered as offshoring also investments between regions of different countries but within Europe. Let us now overcome this assumption and focus on the effects of R&D offshoring towards countries outside Europe, as opposed to offshoring within the area. Table 4 presents some descriptive statistics of R&D offshoring both intra and extra Europe. Rather interestingly, less than one-third of R&D offshoring projects are directed towards other European countries (both within and outside the EU), so the bulk of investments is actually directed to non-European countries. As already stressed in a report for the EU (Pro Inno Europe, 2007) the main non-European recipients of R&D offshoring are China and India, then are developed countries and other South-East-Asian countries. Other developing countries, which include important destinations such as Brazil and Russia, attract also a considerable number of projects. In Table 5 we assess the effect of offshoring R&D within Europe versus non-European countries. Results suggest that offshoring R&D within Europe does not bring significantly different productivity gains than offshoring R&D outside Europe: both the coefficients are is similar in magnitude, but they are rather imprecisely estimated. When we consider R&D offshoring towards specific areas, we find that the effect on productivity growth is always positive, including the case of China, but in most cases it is imprecisely estimated. The effect is larger and significant in the case of R&D offshoring toward South-East-Asian countries. Conversely, regions offshoring R&D more intensively towards India experience a significantly lower productivity growth. This be explained by a number of concurrent factors. For example, it could signal that offshoring towards India substitute for R&D activities in the home regions, thus decreasing productivity, that reverse technology is less effective from Indian affiliates or that investing in India is not associated with firm growth at home (and thus reallocation of market share to offshoring firms). At any rate, a closer inspection of the patterns of R&D offshoring in India is necessary, in order to better grasp the reasons for the peculiar effect that these investments have on European regions' productivity growth.

Table 4: Descriptive statistics on R&D offshoring, 2003-2006

variable	mean	p50	p90	p95	p99	max
OFF^{rd}	.549	0	1	2	12	29
OFF^{rd} - *intra europe*	.171	0	0	1	4	9
OFF^{rd} - *extra europe*	.377	0	1	2	10	20
OFF^{rd} - *developed*	.071	0	0	0	2	5
OFF^{rd} - *china*	.104	0	0	1	3	6
OFF^{rd} - *india*	.074	0	0	0	2	6
OFF^{rd} - *south east asia*	.047	0	0	0	2	5
OFF^{rd} - *others*	.079	0	0	0	2	7

4.5 Concluding remarks

In recent years, multinational firms have increasingly resorted to offshoring of R&D activities, in order to cope with the need to integrate differentiated sources of knowledge and implement a faster and cheaper innovative process. This is part of the broader phenomenon of Global Innovation Networks (GINs), where domestic and foreign R&D labs (as well as production and marketing departments) of multinational and non-multinational firms interact within and across firms boundaries for the global generation and diffusion of innovation. This process has increasingly involved emerging countries and raised fears that the knowledge base in advanced economies may be 'hollowed out'.

Table 5: The effect of offshoring on EU regional productivity growth (OLS regressions)

	(1)	(2)
$OFF(d)_{t-1}$	0.0062***	0.0058**
	(0.0024)	(0.0024)
$OFF(n)_{t-1}$	-0.0002***	-0.0002***
	(0.0001)	(0.0001)
$OFF(n)^{rd\text{ - }intra\ europe}_{t-1}$	0.0015	0.0022
	(0.0019)	(0.0020)
$OFF(n)^{rd\text{ - }extra\ europe}_{t-1}$	0.0014	
	(0.0010)	
$OFF(n)^{rd\text{ - }developed}_{t-1}$		0.0020
		(0.0025)
$OFF(n)^{rd\text{ - }china}_{t-1}$		0.0029
		(0.0019)
$OFF(n)^{rd\text{ - }india}_{t-1}$		-0.0061***
		(0.0022)
$OFF(n)^{rd\text{ - }south\ east\ asia}_{t-1}$		0.0045***
		(0.0016)
$OFF(n)^{rd\text{ - }others}_{t-1}$		0.0010
		(0.0021)
$INW(d)_{t-1}$	-0.0055**	-0.0059**
	(0.0023)	(0.0023)
$INW(n)_{t-1}$	0.0003***	0.0003***
	(0.0001)	(0.0001)
$\Delta_{t,t-1}kl$	0.2429***	0.2462***
	(0.0804)	(0.0810)
Constant	0.0222***	0.0221***
	(0.0036)	(0.0036)
Country dummies	Yes	Yes
N. observations	769	769
N. regions	265	265

At the same time, economic research has emphasized that R&D offshoring may actually strengthen the home economies, by allowing some form of reverse technology transfer, firm growth and spillovers. This paper investigates a part of this story, focusing on 'captive' offshoring of R&D[17] and investigating to what extent productivity growth in 265 EU regions (NUTS 2) is affected by the propensity (and extent) of firms in the regions to set up facilities abroad, with special reference to the creation of R&D labs. Our results suggest that offshoring regions experience a higher productivity growth, but this positive effect fades down with the number of investment projects carried out abroad. However, these 'decreasing returns' to offshoring do not seem to occur in the case of R&D. In fact, our estimates suggest that one additional R&D offshoring project is associated with a significantly higher regional productivity growth the next year. This is effect is positive regardless of whether offshoring occurs within Europe or towards other emerging or advanced countries (with the exception of India).

Although more research is needed in order understand the channels and conditions under underlying the positive effect of R&D offshoring on productivity growth at home, our study sends a reassuring message to EU policymakers, since it supports the idea that carrying out R&D abroad (even in China and other emerging economies) strengthens —rather than 'hollows out'— European sources of competitiveness.

[17] Thus we do not address the various aspects of GINs, such as the outsourcing of R&D, or the establishment of collaborative linkages with firms in foreign countries (with or without having a local R&D lab or other firm's facilities)

Appendix A

A.1. Labour productivity

Some remarks on the labour-productivity measure should be made. First, data on the regional employment are drawn from the European Regional Database. We chose to use this source, since the employment series of the Regio database has a higher number of missing values which would have decreased the set of regions under analysis. The downside of this choice is that in the version of the European Regional Database available to us, values for 2005 and 2006 were forecast. However, we checked that correlation with the actual (non missing) values, reported by the more updated Regio dataset is very high (0.95). Second, in order to build deflators for regions belonging to Cyprus, Estonia, Latvia, Lithuania and Malta (which are actually all single-region country) we have used the series of price index in the previous release of the EU KLEMS database (2008) given that they were not available in the last release yet. Third, for Bulgarian and Romanian regions we have used the 'Eurozone' series of price index, given that the national series were not available in the database.

A.2. Capital-labour ratio

We have included the capital-labour ratio (KLijt) in our regressions, in order to control for the regional factor share. The variable has been computed as the ratio of the regional capital stock (Kijt) to employment (thousands) in the region (Lijt). The capital stock at the regional level, has been obtained applying the perpetual inventory method (PIM) to the series of capital investments in the region (at 1995 prices in millions of euro)18 taken from the European Regional Database. As for the employment series, capital investments' information for 2005 and 2006 are forecast.

We followed Hall and Mairesse (1995), and the capital stock at the beginning of the first year has been defined as below:

$$K_{ij,t=1} = \frac{I_{ij,t=1}}{g_{ij} + \delta}, \qquad (6)$$

where Iij,t=1 is the amount of capital investments taken by the region i in the first year of the series19 , gij is the rate of growth of capital investments observed in the region in a given span of time (in this case is from 1995-200220), and δ is depreciation rate which has been set equal to 7.5%21 . Capital stock from the second year onward has been computed using the following formula:

[18] The series comprehend aggregate investments by the following sectors: agriculture, total energy and manufacturing, construction, market and non-market services

[19] We start computing the capital stock series at 1995 up to 2006, even if in the econometric analysis we use the values from 2002 to 2006. The main motivation relates to the possibility to rest on a more reliable capital stock at the left hand side of Equation 7 for the years under analysis.

[20] For Romanian regions the investments' growth rate has been computed for the period 1998-2002, given the lack of data for the years 1995, 1996 and 1997.

[21] As robustness checks we also computed the capital stock assuming depreciation rate of 5% and 10%, and we did not register significantly different results.

$$K_{ij,t} = (1 - \delta) \cdot K_{ij,t-1} + I_{ij,t}. \quad (7)$$

The variable has been included in logs in the econometric analysis, klijt .

A.2.1. Other regional characteristics

In this Section, we detail how regional characteristics — i.e. the level of human capital, the technological capital and the regional industrial mix — have been measured.

Human capital (HCAPijt) has been proxied by the (log of the) share of population aged 25 or more (thousands) with tertiary-type education degree (ISCED 5-6) in each region. Information come from the EU Regional Database, maintained by Eurostat.22

The regional technological capital (T ECHijt) has been proxied by the ratio of the stock of patents applications (IN N OVijt) to the total population (thousands) in the region (P OPijt). The stock has been recovered using information on the number of patent applications to the European Patent Office (EPO) coming from each European region, which are available in the database maintained by Eurostat22. Data on total population comes from the database developed by Cambridge Econometrics. The stock for the years t = (2003,2004,2005,2006) has been computed as the sum of the patent applications in all sectors in the previous five years (P AT AP Pijt):

$$INNOV_{ij,t} = \sum_{t=t-5}^{t} PATAPP_{ijt}. \quad (8)$$

The ratio has been included in logs in the econometric analysis, techijt .

We have taken into account the regional industrial mix (SHs*ijt), by introducing the share of employment in six broad sectors s* of the regional economy: Agriculture, hunting, forestry and fishing (AC), Electricity, gas, water supply and Constructions (EF), High-tech manufacturing & Medium high-tech manufacturing (HD), Medium low-tech manufacturing & Low-tech Manufacturing (LD), Knowledge-intensive services (KI) and Less knowledge-intensive (LKI) services. Each share has been computed in the following way:

$$SH_{s*ijt} = \frac{L_{s*ijt}}{L_{ijt}}$$

where Lijt and Ls*ijt denote, respectively, total employment in the region i which belongs to country j (thousands), and employees belonging to the sector s*. To avoid multicollinearity we introduced five coefficients in the regressions. The excluded sectoral share is the AC sector (Agriculture, hunting, forestry, fishing, mining and quarrying). Data regarding employees in each

[22] Data on patent applications are regionalised on the basis of the investors' residence: in the case of multiple investors proportional quotas have been attributed to each region.

sector come from the database maintaned by Eurostat. Data on employment by sectors are missing for a number of (region/year) observations; in order not to loose those observations, we have used linear interpolation to fill the gaps for all the observations that were 'missing', but which had 'non-missing' observations the year before and the year after the missing ones. We further filled in a small amount of missing observations in the High-tech manufacturing sector (which showed the highest number of missing observations) as the difference between total regional employment and the sum of employees in all the others sectors (AC, EF, Medium-high tech manufacturing, Medium-low tech manufacturing, Low-tech manufacturing, KI, LKI).

We have controlled for the degree of concentration/diversification of the regional industrial mix. Following the literature (see Cingano and Schivardi, 2004; Bracalente and Perugini, 2008, among others), we have used the Herfindahl-Hirschman index as a proxy for concentration/diversification computed as follows:

$$HHI_{ijt} = \sum_s SH^2_{sijt} = \sum_s \left(\frac{L_{sijt}}{L_{ijt}}\right)^2, \qquad (9)$$

where SHsijt are a more detailed disaggregation of the employment shares defined above. In fact, as elements of the HHI we take into account 8 broad sectors, s: Agriculture, hunting, forestry and fishing (AC), Electricity, gas, water supply and Constructions (EF), High-tech manufacturing (HTD), Medium high-tech manufacturing(MHTD), Medium low-tech manufacturing (MLTD), Low-tech Manufacturing (LTD), Knowledge-intensive services (KI) and Less knowledge-intensive (LKI) services. In particular, we consider the HTD and the MHTD as two separate sectors here, and the same holds for the LTD and the MLTD which are considered separate elements of the HHI23 . The HHI index, which is equal to '1' for regions with all employees in one sector and which goes toward '0' for more diversified regional structures, allows us to control for the sectoral concentration/variety of the region, while by introducing the SHs∗ it ratios, we account for the different 'quality' of the industrial mix. For any given level of HHI we expect regional productivity to be higher in regions where the share of high-value added activities (such as High-tech Manufacturing and Knowledge-intensive services) is higher24.

The HHI enters in logs in the econometric analysis, hhi.

The taxonomy of broad sectors —which have been used in order to build the Herfindahl index of diversification and the shares of employment which proxy the regional industrial mix— has been taken from the list which has been proposed by Eurostat in the EU Regional Database. We cross-refer the reader to the technical repost by Felix (2006) for further details on the employed taxonomy.

Sectors are presented in Table A.2.

[23] The detailed taxonomy of sectors s is presented in Table A.2 of the Appendix.

[24] The use of different levels of aggregation in the *H HI* with respect to these employments shares is motivated both by the achieved greater precision of the Herndahl-Hirschman index, which aims at capturing the variability in the regional industrial mix, and –on the contrary– by the attempt to minimize over-specification in the estimates of the coefficients of the sectoral employment shares.

A.3. List of regions

The list of the NUTS 2 regions which have been considered in the baseline Specification (3) is reported in Table A.3. Overall, we can account for 255 regions (and 746 observations) belonging to the EU in our analysis, for the period 2003-2006.

Table A.1: Descriptive statistics, 2003-2006

Variable	Notation	Unit	Count	Obs.	Mean	Std. Dev	p10	p25	p50	p75	p90
Labour productivity	y	ratio (log)		1017	3.360	0.751	1.956	3.202	3.651	3.856	3.948
Capital-labour ratio	kl	ratio (log)		1036	4.148	0.863	2.714	3.949	4.387	4.753	4.923
Human capital	$hcap$	ratio (log)		1010	-1.468	0.378	-2.040	-1.728	-1.403	-1.189	-1.035
Herfindahl index	hhi	formula (log)		922	-1.377	0.177	-1.602	-1.514	-1.391	-1.246	-1.144
Innovation stock	$tech$	formula (log)		1036	-0.992	1.859	-3.721	-2.360	-0.416	0.397	0.982
Share of other industies	SH_EF	share		922	0.089	0.023	0.062	0.072	0.084	0.101	0.119
Share of High-tech man.	SH_HT	share		922	0.066	0.035	0.028	0.043	0.060	0.084	0.112
Share of Low-tech man.	SH_LT	share		922	0.125	0.046	0.068	0.088	0.122	0.153	0.191
Share of KI svcs	SH_KIS	share		922	0.316	0.088	0.212	0.254	0.309	0.379	0.431
Share of LKI svcs	SH_LKIS	share		922	0.336	0.047	0.280	0.312	0.338	0.364	0.392
Labour productivity-growth rate	$\Delta_{(t,t-1)}y$	ratio (log, differences)		1017	0.020	0.044	-0.017	0.003	0.017	0.034	0.059
Capital-labour ratio-growth rate	$\Delta_{(t,t-1)}k$	ratio (log, differences)		1036	0.022	0.026	-0.003	0.007	0.018	0.032	0.053
Human capital-growth rate	$\Delta_{(t,t-1)}hcap$	ratio (log, differences)		1002	0.039	0.072	-0.037	-0.002	0.036	0.074	0.119
Herfindahl index-growth rate	$\Delta_{(t,t-1)}hhi$	formula (log, differences)		891	0.009	0.035	-0.033	-0.009	0.008	0.028	0.048
Innovation stock-growth rate	$\Delta_{(t,t-1)}tech$	formula (log, differences)		1036	0.047	0.156	-0.079	-0.018	0.033	0.081	0.174
Share of other industries-growth rate	$\Delta_{(t,t-1)}$ SH_EF	share (differences)		891	0	0.009	-0.010	-0.004	0.001	0.006	0.012
Share of High-tech man.-growth rate	$\Delta_{(t,t-1)}$ SH_HT	share (differences)		891	0	0.009	-0.011	-0.006	-0.001	0.004	0.009
Share of Low-tech man.-growth rate	$\Delta_{(t,t-1)}$ SH_LT	share (differences)		891	0	0.011	-0.016	-0.009	-0.002	0.003	0.009
Share of KI svcs.-growth rate	$\Delta_{(t,t-1)}$ SH_KI	share (differences)		891	0	0.015	-0.012	-0.003	0.004	0.013	0.022
Share of LKI svcs.-growth rate	$\Delta_{(t,t-1)}$ SH_LKIS	share (differences)		891	0	0.016	-0.017	-0.009	0.002	0.010	0.020

Table A.2: Breakdown of sectors (Nace Rev. 1.1 codes)

Agriculture, hunting, forestry and fishing	01 to 05 Agriculture, hunting, forestry and fishing
Electricity, gas, water supply and constructions	40 to 41; 45 Electricity, gas, water supply and constructions
High-tech Manufacturing	30 Manufacture of office machinery and computers 32 Manufacture of radio, television and communication equipment and apparatus 33 Manufacture of medical, precision and optical instruments, watches and clocks
Medium High-tech Manufacturing	24 Manufacture of chemicals and chemicals products 29 Manufacture of machinery and equipment n.e.c. 31 Manufacture of electrical machinery and apparatus n.e.c. 34 and 35 Manufacture of transport equipment
Low and medium-low-tech Manufacturing	15 to 22 Manufacture of food products, beverages and tobacco; textiles and textile products; leather and leather products; wood and wood products; pulp, paper and paper products,publishing and printings 23 Manufacture of coke, refined petroleum products and nuclear fuel 25 to 28 Manufacture of rubber and plastic products; basic metals and fabricated metals product; other non-metallic mineral products 36 to 37 Manufacturing n.e.c.
Knowledge-intensive services	61 Water Transport 62 Air Transport 64 Post and telecommunications 65 to 67 Financial intermediation 70 to 74 Real estate, renting and business activities 80 Education 85 Health and social work 92 Recreational, cultural and sporting activities
Less knowledge-intensive services	50 to 52 Motor trade 55 Hotels and restaurants 60 Land transport ; transport via pipelines 63 Supporting and auxiliary transport activities; activities of travel agencies 75 Public administration and defence; compulsory social security 90 Sewage and refuse disposal, sanitation and similar activities 91 Activities of membership organization n.e.c. 93 Other service activities 95 Activities of households as employers of domestic staff 99 Extra-territorial organizations and bodies

Table A.3: List of the 255 regions considered in the present study, by country

NUTS	Name	# regions	NUTS	Name	# regions	NUTS	Name	# regions	NUTS	Name	# regions
Austria		9	Germany		39	ITD3	Veneto		ES41	Castilla y Len	
AT11	Burgenland		DE11	Stuttgart		ITD4	Friuli-Venezia Giulia		ES42	Castilla-la Mancha	
AT12	Niedersterreich		DE12	Karlsruhe		ITD5	Emilia-Romagna		ES43	Extremadura	
AT13	Wien		DE13	Freiburg		ITE1	Toscana		ES51	Catalua	
AT21	Krnten		DE14	Tbingen		ITE2	Umbria		ES52	Comunidad Valenciana	
AT22	Steiermark		DE21	Oberbayern		ITE3	Marche		ES53	Illes Balears	
AT31	Obersterreich		DE22	Niederbayern		ITE4	Lazio		ES61	Andalucia	
AT32	Salzburg		DE23	Oberpfalz		ITF1	Abruzzo		ES62	Regin de Murcia	
AT33	Tirol		DE24	Oberfranken		ITF2	Molise		ES70	Canarias (ES)	
AT34	Vorarlberg		DE25	Mittelfranken		ITF3	Campania		Sweden		8
Belgium		11	DE26	Unterfranken		ITF4	Puglia		SE11	Stockholm	
BE10	Brussels		DE27	Schwaben		ITF5	Basilicata		SE12	stra Mellansverige	
BE21	Prov. Antwerpen		DE30	Berlin		ITF6	Calabria		SE21	Smland med arna	
BE22	Prov. Limburg (B)		DE41	Brandenburg-Nordost		ITG1	Sicilia		SE22	Sydsverige	
BE23	Prov. Oost-Vlaanderen		DE42	Brandenburg-Sdwest		ITG2	Sardegna		SE23	Vstsverige	
BE24	Prov. Vlaams Brabant		DE50	Bremen		Latvia		1	SE31	Norra Mellansverige	
BE25	Prov. West-Vlaanderen		DE60	Hamburg		LV00	Latvia		SE32	Mellersta Norrland	
BE31	Prov. Brabant Wallon		DE71	Darmstadt		Lithuania		1	SE33	vre Norrland	
BE32	Prov. Hainaut		DE72	Gieen		LT00	Lithuania		United Kingdom		36
BE33	Prov. Lige		DE73	Kassel		Luxembourg		1	UKC1	Tees Valley and Durham	
BE34	Prov. Luxembourg (B)		DE80	Mecklenburg-Vorpommern		LU00	Luxembourg		UKC2	Northumberland, Tyne and Wear	
BE35	Prov. Namur		DE91	Braunschweig		Malta		1	UKD1	Cumbria	
Bulgaria		6	DE92	Hannover		MT00	Malta		UKD2	Cheshire	
BG31	Severozapaden		DE93	Lneburg		Poland		16	UKD3	Greater	
BG32	Severen tsentralen		DE94	Weser-Ems		PL11	Ldzkie		UKD4	Lancashire	
BG33	Severoiztochen		DEA1	Dsseldorf		PL12	Mazowieckie		UKD5	Merseyside	
BG34	Yugoiztochen		DEA2	Kln		PL21	Malopolskie		UKE1	East Riding and North Lincolnshire	
BG41	Yugozapaden		DEA3	Mnster		PL22	Slaskie		UKE2	North Yorkshire	
BG42	Yuzhen tsentralen		DEA4	Detmold		PL31	Lubelskie		UKE3	South Yorkshire	
Cyprus		1	DEA5	Arnsberg		PL32	Podkarpackie		UKE4	West Yorkshire	
CY00	Cyprus		DEB1	Koblenz		PL33	Swietokrzyskie		UKF1	Derbyshire and Nottinghamshire	
Czech Republic		8	DEB2	Trier		PL34	Podlaskie		UKF2	Leicestershire, Rutland and Northants	
CZ01	Praha		DEB3	Rheinhessen-Pfalz		PL41	Wielkopolskie		UKF3	Lincolnshire	
CZ02	Stredn Cechy		DEC0	Saarland		PL42	Zachodniopomorskie		UKG1	Herefordshire, Worcestershire and Warks	
CZ03	Jihozpad		DED1	Chemnitz		PL43	Lubuskie		UKG2	Shropshire and Staffordshire	
CZ04	Severozpad		DED2	Dresden		PL51	Dolnoslaskie		UKG3	West Midlands	
CZ05	Severovchod		DED3	Leipzig		PL52	Opolskie		UKH1	East Anglia	
CZ06	Jihovchod		DEE0	Sachsen-Anhalt		PL61	Kujawsko-Pomorskie		UKH2	Bedfordshire, Hertfordshire	
CZ07	Stredn Morava		DEF0	Schleswig-Holstein		PL62	Warminsko-Mazurskie		UKH3	Essex	
CZ08	Moravskoslezko		DEG0	Thringen		PL63	Pomorskie		UKI	London	
Estonia		1	Greece		12	Portugal		5	UKJ1	Berkshire, Bucks and Oxfordshire	
EE00	Estonia		GR11	Anatoliki Makedonia, Thraki		PT11	Norte		UKJ2	Surrey, East and West Sussex	
Finland		5	GR12	Kentriki Makedonia		PT15	Algarve		UKJ3	Hampshire and Isle of Wight	
FI13	It-Suomi		GR13	Dytiki Makedonia		PT16	Centro (PT)		UKJ4	Kent	
FI18	Etel-Suomi		GR14	Thessalia		PT17	Lisboa		UKK1	Gloucestershire, Wiltshire and North Somerset	
FI19	Lnsi-Suomi		GR21	Ipeiros		PT18	Alentejo		UKK2	Dorset and Somerset	
FI1A	Pohjois-Suomi		GR22	Ionia Nisia		Romania		8	UKK3	Cornwall and Isles of Scilly	
FI20	land		GR23	Dytiki Makedonia		RO11	Nord-Vest		UKK4	Devon	
France		22	GR24	Sterea Ellada		RO12	Centru		UKL1	West Wales and The Valleys	
FR10	le de France		GR25	Peloponnisos		RO21	Nord-Est		UKL2	East Wales	
FR21	Champagne-Ardenne		GR30	Attiki		RO22	Sud-Est		UKM2	Eastern Scotland	
FR22	Picardie		GR42	Notio Aigaio		RO31	Sud		UKM3	South Western Scotland	
FR23	Haute-Normandie		GR43	Kriti		RO32	Bucuresti		UKM5	North Eastern Scotland	
FR24	Centre		Hungary		7	RO41	Sud-Vest		UKM6	Highlands and Islands	
FR25	Basse-Normandie		HU10	Kzp-Magyarorszg		RO42	Vest		UKN0	Northern Ireland	
FR26	Bourgogne		HU21	Kzp-Dunntl		Slovakia		4	Netherlands		12
FR30	Nord-Pas-de-Calais		HU22	Nyugat-Dunntl		SK01	Bratislavsk		NL11	Groningen	
FR41	Lorraine		HU23	Dl-Dunntl		SK02	Zpadn Slovensko		NL12	Friesland (NL)	
FR42	Alsace		HU31	szak-Magyarorszg		SK03	Stredn Slovensko		NL13	Drenthe	
FR43	Franche-Comt		HU32	szak-Alfld		SK04	Vchodn Slovensko		NL21	Overijssel	
FR51	Pays de la Loire		HU33	Dl-Alfld		Slovenia		1	NL22	Gelderland	
FR52	Bretagne		Ireland		2	SI0	Slovenia		NL23	Flevoland	
FR53	Poitou-Charentes		IE01	Border, Midlands and Western		Spain		17	NL31	Utrecht	
FR61	Aquitaine		IE02	Southern and Eastern		ES11	Galicia		NL32	Noord-Holland	
FR62	Midi-Pyrnes		Italy		21	ES12	Principado de Asturias		NL33	Zuid-Holland	
FR63	Limousin		ITC1	Piemonte		ES13	Cantabria		NL34	Zeeland	
FR71	Rhne-Alpes		ITC2	Valle d'Aosta/Valle d'Aoste		ES21	Pais Vasco		NL41	Noord-Brabant	
FR72	Auvergne		ITC3	Liguria		ES22	Comunidad Foral de Navarra		NL42	Limburg(NL)	
FR81	Languedoc-Roussillon		ITC4	Lombardia		ES23	La Rioja				
FR82	Provence-Alpes-Cte d'Azur		ITD1	Provincia Autonoma Bolzano-Bozen		ES24	Aragn				
FR83	Corse		ITD2	Provincia Autonoma Trento		ES30	Comunidad de Madrid		Total		255

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5 THE IMPACT OF GLOBAL INNOVATION NETWORKS IN NATIONAL SYSTEMS – THE CASE OF DANISH FOOD INDUSTRY

Authors:

Susana Borrás* and Stine Haakonsson (Copenhagen Business School, CBS, Denmark, participant no.4)

Abstract: The rise of global innovation networks poses a fundamental and unsolved question about their impact on national innovation systems in Europe. This paper looks at this asking, to what extent and how have global innovation networks mobilized national innovation networks? With an analysis of the Danish food industry, this paper examines the differential impact of global innovation systems according to their knowledge features (knowledge augmenting or knowledge exploiting). Looking at four dimensions of national network mobilization, the findings of our qualitative data show that global innovation networks which augment knowledge tend to mobilize national networks by widening their scope, their size and their content, and by a concurrent process of internationalization of national innovators. This is not the case in global innovation networks based on knowledge exploitation. Both types, though, show similar levels of formalized intellectual property protection in their interactions at the national level.

Keywords: Denmark*;* Foreign Direct Investment*;* Globalization of R&D; Innovation Networks; Multinational Companies; National Innovation System.

* Corresponding author: Tel: (+45) 38.15.35.68, email address: sb.dbp@cbs.dk.

5.1 Introduction

During the past two decades there has been an increasing internationalization of innovation-related interactions. This is reflected in statistical indicators of inward and outward research and development (R&D) based foreign direct investment (FDI), in the number of scientific papers with co-authors from different nationalities, and in the number of collaborations with partners from abroad. There are several drivers that might explain such dynamics, namely, the need to access complementary knowledge, the need to adapt existing knowledge and products to new markets, or the quest for accessing human resources at lower-costs. Sometimes this takes place in a truly global manner linking to other innovating firms and scientists around the globe, most times however this takes place with a regional scope, e.g. within Asia, Europe or North America.

The perspective of this paper is on global innovation networks (GINs) as they are arguably the most exciting expression of all forms of innovation internationalization. Along with the introductory paper of this special issue, GINs are defined here as specific forms of contractual collaborations for carrying out innovative activities performed in conjunction by different types of organizations (large and small national and multinational firms, universities, suppliers, subsidiaries, public research laboratories, etc), and which, in so doing, cut across national boundaries while acquiring a global reach. The 'formal' aspect of GINs is to define them on the basis of some clearly identifiable contractual relations, which can range from a short-term to a long-term basis. Likewise, the motivation to engage in GINs might depend on different aspects, ranging from market seeking knowledge exploitation-only purposes, to knowledge augmenting only purposes (Kuemmerle 1999). As mentioned above, the 'global reach' of GINs might vary substantially. Important for this paper is the observation that firms and other organizations in emerging markets like Brazil, China, India and South Africa are increasingly involved in these innovation networks, expanding geographically the reach of the still dominant innovation networks among Triad-countries (Europe, Japan and USA) (Ernst, 2006) (Bardhan and Jaffee, 2010).

Yet, the topic of global innovation networks has become politically sensitive as it touches upon the question whether they have negative or positive effects on national innovation systems. In developed countries, particularly in Europe, the debate has tended to be rather negative and with strong techno-nationalist tones, as it has been mostly associated with outward R&D. However, in spite of these political debates there is still scarce empirical evidence on this matter.

This paper looks at how the bidirectional relations of global innovation networks affect pre-existing patterns of national system of innovation, and in particular how these networks are transforming knowledge dynamics and actors' interactions in the national system. Are the dynamics of established innovation networks in the national innovation systems generally transformed due to the growing global reach of innovation collaborations? What impact on national network dynamics can be identified as a consequence of global innovation networks?

The paper proceeds as follows. Based on a critical review of the literature on this matter, the next section elaborates an analytical framework identifying deductively two dimensions of the possible impact that global innovation networks might be exercising on national systems of innovation, with particular view on Europe. The choice of the Danish food industry is justified on the basis of a research design that aims at generating some preliminary generalizable empirical results. After that, a succinct description of the Danish food industry innovation system is at point. This industrial sector has for the bio-tech related part experienced a remarkable process of GINs during the past decade while the more 'traditional' part continues to be mostly regionally (European) integrated.

The sections that follow examine one by one each of the two dimensions of GINs impact. This is deducted from the analytical framework based on a differentiated effect on the 'network mobilization' according to the nature of the knowledge exchanged and developed within the global network. This is done on the basis of two sets of data, namely, system-level data on the patterns and dynamics of this sectoral innovation system during the past two decades, and a detailed examination of four individual case studies of GINs which are led by core firms in the Danish food industry.

5.2 Analyzing the impact of global innovation networks on innovation systems

The question of how far and how global innovation networks impact innovation networks dynamics within national innovation systems remains unsolved in the literature. Looking at the global off-shoring and outsourcing of R&D, the literature remains rather inconclusive when it comes to determine its overall impact in the home economy. Focusing mainly on the R&D off-shoring of the IT sector, USA's Lieberman's report points mostly at the possible negative effects in terms of downward pressure on high skill wages and national security concerns (Lieberman, 2004). In this argument lies the idea that these potential negative effects might be 'hollowing out' the domestic R&D base, forcing a reduction of R&D jobs, and generating technological leakage.

More positive views are expressed in other studies, either seen as an accumulation of positive effects at the firm level by accessing new markets and by improving efficiencies (Hemphill, 2006), or as generating processes of knowledge spillovers through 'brain circulation' rather than a net loss of knowledge competences (Saxenian, 2007). Furthermore, the positive views follow from studies showing that firms' decisions to off-shore R&D are strategically anchored in core innovative areas of the firm, and therefore off-shoring has the effect of strengthening rather than weakening the knowledge base of the company in question (Kotabe, 1990) (Patel and Vega, 1999) (Chen, 2004) (Naghavi and Ottaviano, 2009) (Contractor et al., 2010). A recent analysis of the effects of R&D off-shoring of OECD countries to BRICKST countries (Brazil, Russia, India, China, Korea, Singapore and Taiwan) suggests a positive effect on the knowledge production of home OECD countries in the high tech industrial sectors, but much less so in medium- and low-tech sectors (Piscitello and Santangelo, 2010). Their study is based on a cross-country and cross-industrial perspective, and its unambiguous findings about cross-industrial differences constitutes a useful starting point for understanding the complexity of the impact of innovation globalization on knowledge dynamics in a country.

The literature on the effects of inward R&D FDI shows similar positive-negative views. On the positive side, several studies point at the positive effects of inward R&D FDI in host countries, in particular multinational companies' off-shoring of R&D facilities. These exhibit important differences according to the market they are focusing on, and the type of knowledge they develop. Thus, the assumption that the greater the degree of localization in the host innovation system (i.e. the degree of ties with other organizations) the higher the R&D intensity of R&D related FDI (Westney, 1993), has been largely confirmed in a recent study of Taiwan (Chen, 2007). Whereas developed countries remain the main host of much of R&D related FDI, there is a recent important tendency towards locating R&D activities in developing countries (UNCTAD, 2005). Such trend raises issues about the extent to which such R&D related FDI contributes to economic development by upgrading human resources and capabilities in the host country. On the negative side, inward R&D related FDI might result in a downsizing of the indigenous R&D capacity, a crowding out of the labour market, and increasing technological dependency. Taken together, the recent empirical

findings regarding the impact of outward and inward FDI related R&D (Chen 2007; Piscitello and Santangelo 2010) point towards a differentiated impact on national systems of innovation. Chen's findings underline the relevance the type of knowledge in inward R&D has for the local innovation system; whereas Piscitello & Santangelo point at the relevance of the low-medium-high tech industrial specialization when it comes to the impact of outward R&D.

Yet, in spite of being highly relevant, these empirical findings remain inconclusive. This is because the literature seems to suffer from two interrelated gaps. The first relates to a strong tendency for looking either at the national systems' impact of outward dynamics of innovation (typically in developed countries) or at inward dynamics (typically in developing countries). Although very relevant, these studies show only one part of the story. In omitting the analysis of inward and outward dynamics simultaneously the literature disregards the fact that most of these innovative activities are collaborative and complex in nature. To be sure, the networks involve several forms of inward-outward innovation-related interactions in complex webs of collaborations. For that reason the impact of the bidirectionality of interactions (comprising inward and outward FDI R&D) in national innovation systems deserves careful attention. The second gap in the literature is its overwhelming individual firm-only perspective. This firm approach is certainly useful, but it leaves unattended issues related to the complexity and diversity of organizations involved in innovation networks, the dynamics of the networks through time, and above all, an aggregated impact of these networks dynamics on the innovation system. These aspects need careful empirical consideration, as the sectoral dynamics and systemic features both at the national and global level are likely to be most relevant (Pavitt, 1984) (Malerba, 2002).

Taken together these gaps point towards the problem of scarce empirical evidence about the impact of global innovation networks in national innovation systems has to do with the lack of a holistic empirical approach that puts focus on the innovation networks as such (comprising the networks inward-outward bidirectionality of activities and their complex organization), and that puts focus on the systemic nature of innovation processes (sectoral and national). The aim of this paper is to develop such an approach, studying the impact of global innovation networks (GINs) in national systems of innovation, particularly in Europe. With this purpose in mind, the paper aims at providing an analytical framework with two key features, namely, focusing on the bidirectional dimension of interactions in networks rather than looking at the outward or at inward R&D FDI in isolation; and putting the innovation system at the centre of the analysis beyond (yet complementing) the firms-only approach.

In order to address the question of impact we revert to the institutional economics literature on innovation systems. One of the premises largely confirmed by empirical data is that innovation systems exhibit strong intra-systemic linkages that generate positive knowledge spillovers in the territory (Audretsch and Feldmann, 2004). In a sense, a national system of innovation is defined by a set of dense innovation networks taking place in the territory and shaped by common sets of formal and informal rules that form a complex institutional framework for organizational relations (Freeman, 1991). These intra-systemic linkages in the form of innovation networks express different types of knowledge interaction among the actors within the system, while some organizations operate as well at other levels (e.g. regional or international). The literature considers the 'systemness' of innovation systems to be based on the fact that interactions within the territory generate agglomeration economies (such as industrial clusters) with positive network externalities (knowledge spillovers). For that reason, one of the most relevant questions that remain open is the impact of GINs on national/local innovation systems in terms of these knowledge-based intra-system network interactions.

When discussing this impact we distinguish between the nature of a global innovation network (GIN) according to the knowledge strategies of the firms leading those networks. On the basis of that, we elaborate two sets of hypothesis. We expect that firms' integration in global innovation networks affects the pre-existing forms and contents of inter-organizational interaction *within* the innovation system, and that this varies according to the nature of the network. The reasoning behind this is the understanding that firms' strategies regarding knowledge dynamics within those global networks are different, and hence might affect differently the pre-existing national/local innovation networks. Reverting to the introductory paper of this special issue, we distinguish between GINs which are seeking to expand the firms' existing knowledge with complementing/ exploring knowledge from external sources (knowledge-augmenting GINs), or alternatively GINs based on the exploitation of firms' existing knowledge in order to adapt existing products to given markets (knowledge-exploiting GINs) (Dunning and Narula, 1995) (Kuemmerle, 1999).

In order to study in detail the impact of GINs, we have designed an interview questionnaire for the collection of qualitative data (see Annex 1). The questions revolve around five fundamental aspects where GINs might have affected national/local innovation networks differently. The first aspect is the **scope and size of national innovation networks**. This refers to the number of national organizations involved in such network, and to the overall reach of the network within the national innovation system. We expect that the globalization of innovation networks might affect the size and scope of national innovation networks, either by reducing them (a 'substitution effect' of international partners instead of national partners), or by maintaining them (neutral effect), or by expanding them (creating and sustaining global networks requires knowledge resources that are tapped locally). The second aspect is the **type of organizations** involved in national innovation networks. We would like to examine whether variation in the type of organizations involved in national/local innovation networks (i.e. suppliers, customers, universities, Public Research Organizations, consultancies, etc) has been expanded or reduced as a result of firms' engagement in global innovation networks. Do we see any pattern emerging as to the type of national innovation partners firms are collaborating with because there is a global dimension to their innovation?

The third aspect to be analyzed is the **content of the collaboration** within national innovation networks. The matter to be studied is whether the globalization of innovation collaboration has affected the patterns of collaboration at national level as firms need to approach more specialized national knowledge competences (in contrast to more generic), and whether the role performed by national innovation partners has changed nature accordingly (i.e. more 'support' activities like verifying quality of research undertaken internationally rather than direct knowledge creation activities). Scholarly findings regarding the increased inter-disciplinarity and the increased modularity of knowledge produced and managed globally might tend to suggest that the nature of the collaboration in national innovation networks has changed according to the globalization of innovation.

The fourth aspect is the **concurrent internationalization** of other organizations in national innovation networks. We would like to examine the extent to which key firms in global innovation networks have 'pushed' or indirectly induced (or not) other actors in their previous national innovation networks to internationalize themselves. Do we see a sort of mobilization effect towards internationalization of other parts of the national system, or rather a strong divide between those organizations with global and those with national innovation collaboration? Last but not least, the fifth aspect is the **formalization of interactions** in national innovation networks as a result of global innovation networks. In a context of open innovation firms tend to be more aware of intellectual property right issues. Do we see a pattern in which global innovation networks are more

formalized than those at the national level, or do we see degrees of formalization being equally spread no matter the national-global dimension of open innovation?

Taking these five aspects into consideration, we expect that the impact of global innovation networks (GINs) in the dynamics and patterns of national innovation networks will be different according to the nature of the knowledge that defines the GIN. Hence, our first hypothesis H1 is that GINs characterized by knowledge-augmenting strategies will have a positive impact in the innovation system in terms of expanding the size, the types of organizations, the content of the collaboration, the concurrent internationalization and the degree of formalization in the innovation networks within the national system. The reason behind this assumption is that local firms integrated in GINs which are essentially seeking to expand the knowledge frontier of the involved global partners, need to mobilize and have further access to the knowledge available in their national innovation networks. We call this phenomenon "national network mobilization", as the dynamic of tapping into the knowledge resources in the national system. In contrast to this, our second hypothesis H2 reads that GINs characterized by knowledge-exploiting strategies will tend not to further mobilize local innovation networks in the national system. In other words, that global innovation networks (GINs) based on knowledge exploitation will not affect the size, the type of organizations, the content of the collaboration, the concurrent internationalization nor the degree of formalization of the pre-existing innovation networks in the national system. The logic sustaining this hypothesis is the evidence in developing countries that the integration in global production networks is not always generating positive dynamics within local clusters (Bair and Gereffi, 2001). Hence our starting point is that this might also be the case in the developed world, particularly when globalized innovation networks are knowledge-exploiting rather than knowledge-augmenting. In order to address these two hypotheses we will revert to qualitative data. We will distinguish between two types of GINs, namely, knowledge-augmenting and knowledge-exploiting GINs. On that basis we will examine if the pattern of behavior regarding 'mobilizing local innovation networks' is different among these two types of GINs.

Next sections examine in detail these two hypotheses in the Danish food industry, looking carefully at each of these five aspects identified above. The choice of this particular innovation system is justified on the grounds of three important features that render it a relevant case to answer our research questions. Firstly, this is a sector that has experienced a significant degree of global innovation networking during the past two decades, and it is the most internationalized and innovative food cluster in the European Union (EuropeanClusterObservatory, 2010). Secondly, its mix of low, medium and high-tech segments, and its mix of knowledge-augmenting and knowledge-exploiting nature of global innovation networks will be able to provide a nuanced and differentiated account of the impact that this globalization is having in the national context. And last but not least, the small size of the Danish national system together with the centrality of this sector for the Danish economy (food and beverages count for approximately 20 % of all Danish exports) offers a good case study where the sectoral, national and geographical dimensions of the innovation system are strongly aligned to each other. This particular feature circumvents the analytical problem of distinguishing between the national or the local dimensions of network interactions, as both are the same in Denmark. For these three reasons, the study of this sector aims at generating some preliminary generalizable empirical results.

This article is based on empirical data collected in Denmark in 2010 and 2011. The data set consists of two main sources. The first and most important source of data for the analysis in sections 4 and 5 of this paper is based on four in-depth case studies of global innovation networks with Danish firms as primary leading organization. The case studies are mainly based on 20 formal qualitative

interviews with central innovation managers in these four firms, about the changing patterns and nature of interaction with their national innovation systems during the past 10 years in relation to the growing globalization of their innovation network interactions. For reasons of confidentiality, the name of the four firms will not be disclosed. However, they are among the most innovative, largest and internationalized firms in the Danish food industry. Annex 1 contains the list of interviewees. Annex 2 shows the question guide used in this qualitative part of the analysis. These interviews were complemented with background information based on informal conversations and discussions with at least 11 experts and employees of leading firms in the sector (Annex 1).

Secondly, the quantitative data used to describe the Danish food industry in section 3 is based on sources from the national office Statistics Denmark, and on the survey carried out under the auspices of the INGINEUS project in the early 2010 on the Danish food industry. The INGINEUS survey included companies of five or more employees and excluded locally embedded companies such as local butchers and bakeries. Of the 200 companies receiving the questionnaire, 48 companies responded, meaning a response rate of 24 per cent.

5.3 The Danish food innovation system

The food industry has continuously played a central role in the industrialization and internationalization of the Danish economy. The industry was early known for its relatively high export level within products such as bacon, butter, and dairy. Although the food industry is often perceived as a low technology industry, the Danish economy relies to a certain extent on food production particularly when related to ***innovation***. Moreover, the large Danish food companies are world leaders within the bio-tech segments of food production, predominantly within ingredients and enzymes. Hence, the industry constitutes a strong sectoral innovation system within the Danish economy based on consolidated networks among companies, universities and research centers. It represents a highly innovative and export oriented sector in the European Union (EuropeanClusterObservatory, 2010). This section describes the general features of the Danish food innovation system, looking at its local embeddedness and level of internationalisation of markets, production and innovation. The overall aim is to assess the impact of increased internationalisation of innovation on national food related innovation networks.

The industry origins from a farm based and collaborative economy hosting a large number of small locally embedded companies, mainly cooperatives. As of today, most of these smaller units have merged into fewer but large national players within specialized products such as dairy, ingredients, beer and meat. The industry has developed a strong domestically embedded knowledge pool and a high concentration of different network constructs among farmers, companies, and universities concentrated in established clusters encompassing food as well as other agriculture related industries. These clusters are expressions of widespread forms of collaboration across companies, industries, and public and private actors (see for example (Agrotech, 2009). The clusters are also well embedded in the Danish system of life-long learning focusing on innovation and sustained organizational learning. Moreover, due to the small home economy and increasing costs of equipment and innovation, production, innovation and marketing activities have become increasingly internationalized during the past decades (Landbrugsrådet, 2006).

Today, the industry includes both strong multinational companies (MNCs) and a large number of small and medium sized enterprises (SMEs). For the latter segment, as many products are fresh and that tastes vary over geographical space, most companies produce predominantly for the home and

European markets. However, the MNCs have specialized into products for global consumption. They are generally large companies with truly global market reach beyond Europe; they are highly specialized firms; and are typically engaged in cutting-edge research and innovation activities. The Danish food innovation system currently hosts five of the global leaders in ingredients, yeast and enzymes production. These five have engaged in international innovation networks with knowledge augmenting strategies at different degrees. Meanwhile, the more traditional food producers mainly focus their internationalisation of innovation through networks that seek knowledge exploiting, e.g. expanding their market reach and extending their products' durability.

It is worth noting that the INGINEUS survey revealed that particularly larger firms, i.e. with more than 250 employees, are eminently export-oriented: 38 per cent of the companies in our survey reported their largest market is outside Denmark while 56 per cent of the companies reported a significant share of their sales activity abroad. Likewise, the survey disclosed that larger companies also engage more than the small and medium sized companies (SMEs) in research activities. Even though only 12.5 per cent of the respondents reported 'significant research activities'; 40 per cent of these were companies with more than 250 employees. At the overall level, research activities generally take place at home. In 2008, there were 3512 people employed in research and development (R&D) in the industry of which 60 per cent were in the private sector and 246 food companies carried out R&D in Denmark (Danish Ministry of Science, 2010). Although large companies tend to invest more in research, SMEs innovate through their networks. They collaborate with large companies – either upstream as suppliers to or downstream as customers of the larger (Statistics Denmark, 2008, 2010) .Consequently, the industry collaborates vertically as well as horizontally, particularly within Denmark, through a developed 'farm to fork' integration of production (Hansen, 2005, 2009). In addition to this, there are very strong and formalized forms of collaboration between companies and the Danish universities (INGINEUS Survey and (Danish Ministry of Science, 2010)).

The degree of internationalisation of innovation relate to the technology and products produced. Therefore, companies in the biotech segment of the food industry and those with highly specialized niche markets engaged in knowledge *augmenting* of new and cutting-edge knowledge. In other words, being a world leader in ingredients and/or enzymes requires the ability to attract knowledge and the most qualified researchers within a field. These are certainly factors behind companies' decision to establish international collaborative efforts and research centres outside Denmark. In contrast to this, the internationalisation of firms producing for end-consumers, e.g. beer, dairy, meat, flour etc. is mainly exploitation of existing knowledge. Consequently, internationalisation of innovation in food companies takes place in different forms and may impact the national innovation system in the home economy differently.

In the following two sections the five variables of network mobilization set out in the beginning of this paper will be investigated for innovation networks built on knowledge augmenting and knowledge exploiting strategies. The five dimensions are: scope and size of the network, type of organizations, content of collaboration, concurrent internationalization, and formalization of interactions. The companies investigated are among the largest and most innovative actors in the Danish food industry and include actors predominantly engaged in networks for knowledge-augmenting, for knowledge-exploiting, or a combination of both.

5.4 The impact of *knowledge-augmenting* global innovation networks in national networks

Companies in the food industry engaging in knowledge-augmenting strategies are characterized by being strong international players developing innovation networks across national boundaries and increasingly into new world regions and emerging markets. The companies found in this group have gone through a process of off-shoring R&D, either to locations with a highly specialized work force or to locations in which the companies were already doing marketing and production activities. Currently these companies still have a considerable share of their basic research in Denmark, but their international R&D sites are developing into centres of excellence with strong local network ties to universities and other firms. This is particularly true for the biotech segment of the Danish food industry.

The knowledge-augmenting companies have globalized innovation for three main reasons: Firstly, the costs of R&D are increasing and as most companies in this segment spend more than five per cent of their annual turnover on research, they need to reach large markets to recover the expenses. Secondly, their customers are often lead firms within the global food industry who need ingredients or other components that are adjusted for their diverse markets. Finally, some knowledge is highly specialized and in order to facilitate radical innovation, companies need access to different types of knowledge specialisation, which are rarely available in one geographical location. Consequently, the internationalization ratio (ratio of foreign assets to total sales) among these companies is higher (46.1), than the overall food industry (35.7) (UNCTAD, 2009) . As a result of their competitive situation and their status as upstream lead firms, these companies have established global innovation networks that are 1) covering locations of specialized potential employees, 2) facilitating strong linkages with specialized relevant knowledge institutions, and 3) catering for their customers' needs.

Knowledge-augmenting internationalization strategies have an impact on the **scope and size** of national networks. One innovation manager expressed this as: 'Not all good innovation takes place in Denmark'. This is especially the case when customers are based outside the home market. All the companies in this group report a relatively higher share of R&D investments placed outside Denmark. However, the amounts spend in Denmark have not decreased. The companies explained that they need to balance the need to seek knowledge elsewhere and meanwhile maintain their engagement in the home research community which also allows them to access the best knowledge (home and abroad). One company explained difficulties related to accessing the best human resources in other locations, for example in Japan, where the company was largely unknown. One of the strengths of the national food innovation system is that it also hosts some of the largest global competitors. This generates certain home base dynamics. The companies have their basic research at home while the application and some research projects are mainly internationalized. One explanation is that there is a critical mass for innovation at home and their long-term relationships with universities (seen as world-class research institutions) and suppliers (as partners for co-creation) of machinery. However, their need for expanding their markets requires international engagement in R&D. In fact, these companies have all increased considerably their de facto collaborative arrangements and R&D spending in Denmark.

The innovation and R&D projects carried out internationally have an impact in mobilizing actors in the Danish food innovation system when it comes to **the types of organisations** in national networks. The organisations included in national networks have been undergoing a process of

specialization during the process of internationalising innovation. The companies have long-term relations with universities from which they get inputs to their innovation activities, for example within basic research into why meat gets so easily spoilt. However, this is not without conditionalities. One company explained that: 'We believe that the knowledge capital we can get in Denmark generates efficiency, innovation, and new ways of organizing our work practices. However, we do not have an urge for collaborating with Danish universities if they are not world-class'. The companies also collaborate with customers and suppliers at home as these relations go long back. In general, the relationships with Danish private actors and universities have consolidated along with their internationalisation. Today, many researchers are somehow embedded both in a company and in a university department. The companies have not experienced changes in the types of organisations with whom they engage in their national innovation networks. However, the frequency has increased, as has the amount of research involving Danish partners outside the company.

In terms of the **content of collaboration**, knowledge-augmenting strategies require strong coordination why a large portion of the research needs to be followed and/or situated, distributed and managed from home. In order to coordinate internationalization, innovation activities are increasingly organized as more or less isolated projects. For each such project the global innovation manager will invite a different combination of partners at home and abroad into a specialized team within the field. Hence, coordination and decision-making related to innovation projects are so far kept at home. Meanwhile new ideas may appear elsewhere, the initial development stages are undertaken at home but in collaboration with specialized knowledge centers internationally. Consequently, national network partners are also required to demonstrate and deliver world class capabilities in very specialized product segments. When introducing a new innovation project, for example the introduction of sea wheat as an ingredient, the companies require niche players and available knowledge capacities. Therefore, the companies need a home base environment that attracts the core competencies in such highly specialized fields in order to access the competencies needed in the initial stages of innovation. Consequently, companies increasingly play a role in financing laboratories for universities and support these in attracting the right people. One example is a new sustainability centre at the Danish technical university that managed to attract a highly qualified international team of researchers. This kind of collaboration makes the Danish economy an attractive location for the knowledge workers needed close to these companies' research centres. Consequently we can observe an increased specialization of the national partners engaged in national innovation networks, and a general search to generate more specialized partners in the national knowledge pool.

The process also goes the other way as universities have internationalized their recruitment strategies in order to strengthen the collaboration with companies and their position in the national food innovation networks. Hence, new knowledge is transferred and pulled into the national innovation networks and expected to be captured by national research institutions and universities. This dynamic keeps the industry at the technological frontiers while the companies' (re-)constructing and sustaining local innovation networks brings in new capabilities to the national food innovation system. Meanwhile, the attractiveness of the home economy for R&D investments from foreign companies also rises. Following, as the companies internationalize innovation by tapping into knowledge from elsewhere to be added to their home capabilities, the actors in the national innovation networks also experience a process of internationalization. This can be either as a result of the networks introduced by the MNCs or by the pressure to remain a position as world-class research institutions. Anyhow, this leads to a process of **concurrent internationalisation**. The

same apply to the suppliers, as expressed by one of the companies: 'Danish companies [i.e. suppliers] with global outlook are much more attractive for us than those with national connections only'. This probably has different explanations. One given by one of the MNCs was that to maintain a top position there is a need for accessing and attracting people from elsewhere with existing networks. Another, provided by a key supplier was that MNCs do pressure their partners to stay world class. The partners in the national innovation networks are expected to develop their international contacts and profile as if they want to keep their attractiveness in the national networks.

The MNCs using knowledge augmenting strategies have been through a process of increased **formalization of interactions**. A study from the Danish Patent office revealed that patenting is of high relevance for companies using knowledge augmenting strategies. Three of the most internationalized in innovation also had the highest number of patents filed in the food industry between 2004 and 2008 (Patent_og_Varemærkestyrelsen, 2010). Companies engaged in global innovation networks as knowledge augmenting are also those developing most technological break-troughs and all collaboration takes place under contracts and confidentiality agreements – both in Denmark as well as elsewhere. This was expressed by one manager: 'Leakages of knowledge take place at home as well as in China; we do not see any differences'. This is a consequence of having their core competitors based in the same national innovation system and because external partners engage across these.

Summing up, companies taking part in knowledge-augmenting global innovation networks do not substitute their innovation networks at home while engaging in global innovation collaborations or/and placing R&D investments off shore. Rather, internationalization of innovation is a supplement to their home base and has a ***mobilizing impact*** on their existing networks. So far, none of the knowledge-augmenting companies have downscaled their R&D activities at home. Furthermore, although their networks have changed in nature, the importance of these remains high. One manager of global innovation explained that: 'while the *share* of R&D in Denmark may be decreasing, activities are increasing as the amount invested increases... every time we add a new location; coordination gets ten times more difficult'. Another company explained: 'Internationalisation of R&D is not a process in which some locations are over-taking others in the global game. It is a question about being present globally. If we want to become a serious supplier or partner, we need to be present. And we look more serious if we have local R&D'.[1] Hence, these companies often use a combination of global and national approach in their innovation networking: 'the company needs a mix of brains and competencies from around the world and it can be difficult to attract qualified people to Denmark. Therefore although the Danish R&D site is growing – other locations currently grow faster'.

The Danish innovation partners are used as actors in the global innovation networks within specialized areas of innovation and production. Their role relates to being facilitators and coordinators of globalized innovation projects which are organised as more or less independent projects. A manager in one of the case companies explained: 'Five geographical sites are simultaneously working on the same assignment. This group has the critical mass of skilled people and cultural backgrounds, which is necessary for success. All coordination takes place in Denmark'. Hence, collaboration has become specialized involving experts within the network at home and

[1] The companies' understanding of the consequences of internationalisation of innovation is of course one side of the story, however triangulating these views with those met in their Danish suppliers and academia gives the same picture.

abroad. Therefore the Danish actors are included in the global teams and can better access external knowledge through their networks. Meanwhile, the Danish food innovation system is under pressure to remain a key location, which results in a high performance demand on the Danish research institutions. Knowledge creation is embedded in the national innovation system, as the long-standing tradition of national collaboration between firms, research institutions and universities. However, according to our cases, the mobilisation of the national innovation network is likely to be higher for network partners that already have an international outlook.

5.5 The impact of *knowledge-exploiting* global innovation networks in national networks

Companies engaged in the knowledge-exploiting global innovation networks are characterized by producing processed foods for end-consumers. These companies tend to localize their R&D and innovation at home or within Europe. Hence, most innovation takes place through national or regional (European) networks, including actors within their value chain (upstream and downstream) or national universities. The Danish food industry consists of strong clusters (Hansen 2009) with a high level of vertical integration (e.g. in the food chain 'from farm to fork' and the cooperative company model) and horizontal integration (e.g. inter chain collaborations within IT and machinery). This segment is dominated by small and medium-size firms (SMEs). For the larger firms in this segment innovation networks may also include Scandinavian or European partners, who are often internalized through mergers and acquisitions. Therefore, these "global" innovation networks rarely reach beyond the regional economy. Companies in this segment have generally more moderate levels of investment in R&D and innovation than in the knowledge-augmenting segment, and most innovation is incremental, e.g. into improving and/or enhancing raw materials, production processes or product quality/durability; typically with the purpose of reaching new markets. Consequently, these networks are not truly global, and they rarely provide break through 'new to the world' innovations but operate within their product fields. As the firms in these networks have focused on brands and end-consumer markets, competition is high. Consumers are generally very sensitive in regard to pricing of final foods. This segment of the food industry is vulnerable to changes in the economy and relies on national public funding for research and standardization, for example through the benefit schemes in the Danish public technical and certification laboratories.

Innovation in those networks is often initiated by a strategy to entry into a new market (e.g. China) or a new market segment (e.g. young people). Hence, internationalization of innovation is predominantly market oriented. Some of the larger companies in this segment are owned cooperatively by the farmers. As a consequence of this ownership structure these firms orient towards national networks and they collaborate within their value chain (with customers and suppliers) and national universities and research organizations. These companies draw heavily on the existing national food innovation system in order to develop their products and allowing them to capture new markets. Hence, due to the dominance of small-medium company sizes and the expenses of bringing products to the market, innovation involves to a larger extent a wider number of actors at home than abroad.

Companies engaged in home exploiting strategies have developed global networks over the last decade, although these networks do not seem to have had much impact on the **scope and size** of the national innovation networks and overall strong national presence. As R&D and innovation is

highly localized in the national context, these companies are much more focused on creating home environments than on putting pressure on their national partners to engage internationally. Generally speaking the companies in this segment of the food industry are increasingly engaging in collaborative innovation; however the overall size of the national networks has not increased. Instead it has intensified pre-existing collaborations ('we have moved closer to our partners'). So far the companies find the knowledge they need mostly in Denmark, without any substantial change in their size or scope. This means that, the limited internationalization (mostly regionalization) of the knowledge-exploiting innovation networks of those companies; we see no mobilization effect on the scope and size of their pre-existing national innovation networks.

The **types of organizations** involved in national innovation networks do not seem to have changed substantially either. Danish firms in this segment of the food industry have traditionally had very strong relations with national public universities and public research organizations, as much as their national suppliers and customers. Public funding continues to play a very important role in these national innovation networks. It is worth noting that, to qualify for public research funding, universities are increasingly required some industrial application to their research. This requirement has reinforced their previous interactions. Accordingly, the four largest Danish universities are seen as the ultimate national partners for innovation. For that reason, the creation of global/regional innovation networks of knowledge-exploiting nature has not affected the types of organizations with which leading firms in those global/regional networks interact with in the national context. In other words, there seems to be a high degree of continuity from previous patterns, and thus no visible impact effect.

The companies interviewed expressed the advantages of accessing international networks, but have done so in a very limited way. The **content of collaboration** in national networks in this segment rarely involves cutting-edge or disruptive knowledge from outside the national system but the home environment is seen as an attractive and supportive environment for food research, not least sufficient. Still, some adjustments have been done in order to operate in foreign markets. By collaborating with foreign partners in international networks Danish companies seek to adjust their products to new market tastes and needs. Furthermore, international collaborations offers them the possibility of complying with mandatory standards and other requirements for accessing new markets (Avermaete, 2003). However, this segment exhibits very low intensity of international/"global" innovation networking, as access to foreign markets seems to be mostly supported by the reinforcement of previously existing patterns in their strong national innovation networks.

Indeed, an example of this effort to reinforce national innovation networks with the aim of accessing foreign markets is the Agro Food Park. This is a local knowledge initiative supporting the exchange of knowledge and creation of networks among national actors within the Danish food industry. This Park formalizes the strong tradition in Denmark for national collaboration between companies in the national value chain, and indicates that the national networking approach dominates over an international networking approach. Some of the large Danish food companies are present in and around this initiative, one of the case companies of this project currently with more than 300 employees in innovation. Part of this engagement with national organizations is the development of new varieties of produce to strengthen the end products. Another important aspect is the pattern of inter-disciplinary and inter-sectoral interaction in the national networks. Our evidence indicates that this has not changed much. This is partly because the degree of internationalisation of these innovation networks is very limited, but partly also because the attempt

to access international markets has reinforced (rather than changed) pre-existing patterns in national innovation networks.

Still, as internationalization of collaboration is limited in this industrial segment, **concurrent internationalization** of national networks is also limited. This limited concurrent internationalisation is partly explained because the leading firms of these networks are relying on their national suppliers and national universities to internationalize themselves. 'We expect our national university partners to keep up with the international level' and: 'Our Danish university partners and suppliers help finding potential international partners for us to collaborate with'. Some companies in this segment have no need to engage with expensive internationalised innovation networks as they report the Danish research base to be sufficient: 'we know where our expertise is and see no need to expand this'. Meanwhile, one of these companies arranges weekly seminars with experts for which the company invites partners in their national network who then spends the whole day with the company. Sometimes these experts are foreign. In addition to this the company share professors with the University of Copenhagen through funding arrangements, and has a large number of Doctoral and Post Doctorates on their pay roll. They expect these researchers to keep up with the cutting edge and be partners in their networks after their PhD or Post Docs. These researchers tend to move on into other national firms or back into national university.

Although the companies mainly collaborate with well-established national partners in innovation, the level of **formalisation** has increased tremendously over the last decade. The issue of intellectual property is also more important today than just five years ago: 'we have established a new department only dealing with contracts and intellectual property rights'. At the overall level the food industry has increased its share of the total Danish patents from six to 13 per cent. Even for these companies in which most research takes place nationally in their Danish head quarters, the consolidation of national collaborations in innovation is characterized by a formalisation. However, it is worth noting that there is no difference between the level of formalization of the national networks and the (few mainly regional) international networks.

Summing up, the global/international innovation networks based on knowledge-exploitation are very few in this segment of the Danish food industry. Besides, these "global"/regional innovation networks include actors along the value chains of the industry or other industries, predominantly in Northern Europe. Firms' willingness to access new foreign markets has not gone through the creation of global networks, but through the reinforcement of pre-existing national innovation networks. This is part of the reason why our findings indicate that there has been ***no mobilization*** impact on national innovation networks in terms of changing their size, scope, content, and other. The only remark in this regard is the fact that national innovation networks have been reinforced, but not transformed.

5.6 Conclusions: the knowledge base of global innovation networks matter for the national system

This paper has elaborated on the different impact of home augmenting and home exploiting knowledge nature of global innovation networks in the national innovation networks. Table 1 below summarizes the findings according to these two different global innovation networks.

When studying the impact of global innovation networks in the sectoral innovation system in Europe, we formulated two hypotheses according to the type of knowledge in those global

networks. The first of the hypothesis suggests that global innovation networks characterized by firms' knowledge-*augmenting* strategies will have positive impact in the national innovation systems as they stimulate the national innovation networks within the national system by setting new demands to the local firms and universities, and by bringing and demanding new cutting-edge knowledge into the system. In contrast to this, the second hypothesis read that global innovation networks characterized by knowledge-*exploiting* strategies will not have the same mobilizing impact, as their approach to the national innovation networks will not change substantially.

The study of the Danish food sectoral innovation system has generally confirmed these two overall hypotheses. This system is particularly amenable to this study because it has two distinct segments of firms operating in international markets, namely, one with knowledge-augmenting innovation networks worldwide as it operates in a truly global reach, and another segment which is mostly national-oriented when it comes to innovation activities but export-oriented in regional markets. The knowledge-exploitation nature of the latter means that internationalization is relatively limited to incremental innovation for product- adaptation to new markets, and as shown in the previous sections, that innovation is mainly conducted with national rather than with international innovation partners.

Table 1: The impact of global innovation networks on national innovation networks

	Knowledge-augmenting global networks	**Knowledge-exploiting global/regional networks**
Size and scope of networks	Expanding innovation networks home and abroad (most expansion abroad)	Maintaining and consolidating national networks
Type of organisations	Relatively expanding the types of organizations in national networks Only world class partners admitted in national networks.	Maintaining and consolidating previous types of organisations in national networks, including the traditional cross-sectoral dimension.
Content of collaboration	Increasing the degree of knowledge specialisation of partners in national networks. Leading companies assist/fund setting up specialized research centres in national universities to create new knowledge competences in Denmark.	Maintaining the same content of collaboration in national networks, with continuous traditional focus on national research organizations and national public funds.
Concurrent internationalisation	Partners at home remain attractive only if they are themselves internationalized. Concurrent internationalisation because national partners need each others' information about the international	No concurrent internationalization. National partners' internationalization is not perceived as important. Firms in national networks rely on the international contacts of national

	knowledge frontier.	universities – not vice versa.
Formalisation	Formalization of collaboration in contractual relations.	Formalization of collaboration in contractual relations.
	Patents and protection of intellectual property is very important.	Patents and protection of intellectual property is very important.

In particular, our findings show that global innovation networks of knowledge-augmenting nature tend to mobilize their pre-existing national innovation networks by widening their scope and size, their knowledge content (cutting across knowledge disciplines and increasing specialization), and by stimulating a concurrent process of internationalization of national partners. This has a significant impact in the national system, as it has generated a process of adding new knowledge and new actors into the pre-existing national innovation networks. In other words, it has generated new dynamics in national innovation networks. This is not the case in global/regional innovation networks based on knowledge exploitation as the firms involved in them do not seem to have mobilized national innovation networks differently than they did in the past. Admittedly, this has to do with the weak nature of those global innovation networks, because firms have only created few international innovation collaborations. Most efforts to access international export markets have been based on maintaining and consolidating pre-existing national innovation networks.

Having said that, however, only one of the five aspects examined above seems to have followed similar paths regardless of the knowledge nature of the global innovation networks, thus partly rejecting one aspect in our two hypothesis. This refers to the levels of formalized intellectual property protection in their interactions at national level. In this particular aspect, both types of global innovation networks (knowledge-exploiting or knowledge-augmenting) have been experiencing similarly higher levels of formalization interactions in the national context. This means that, formalization is a generalized trend, regardless on the national-international dimension of the networks and regardless the knowledge-nature of those networks.

The findings of this paper tend to indicate that the effects of the increasing globalization of innovation have mixed effects at the national level according to the knowledge-base of that globalization. From the point of view of national systems of innovation studies, it underlines that the 'national' dimension of innovation systems is changing in important ways. Our findings show that national systems are perhaps not 'under strain' (Patel and Pavitt, 2000), but that the globalization trends are significant transformative forces behind some fundamental new dynamics behind firms' differentiated R&D and innovation strategies (Marklund et al., 2009). Policy-makers have long started to understand that challenge. Many European countries have recently launched a series of internationalization programs supporting some of these trends, the most interesting ones of trans-national cooperative nature (Prange-Gstöhl, 2010). However, many questions remain still open, not least about the new types of managerial competences that firms and national policy-makers need in order to secure successful outcomes from these bidirectional dynamics and cross-border innovation networks; about the differences across industrial sectors and across knowledge dynamics; or about the conditions under which policy instruments are responding effectively to these new and accelerated changes in a globalised economy.

Annex 1: Job description of the interviewees

Formal interviews with:

Case study 1

Vice-president for R&D

Research director

Case study 2

Vice President

Senior Director Protein Optimization

Senior Finance, IT and Legal Director in China

Head of R&D in India

Case 3

Manager of Global Innovation

Assistant Product Manager

Professor at the Danish Technical University

Research Manager in China

Innovation manager in South Africa affiliate

Innovation manager in South Africa laboratory

Case study 4

Senior Director of Corporate Research & Innovation

Vice-director - R&D ingredients

Business Area Manager - Nutrition

Head of corporate nutrition

Innovation director

Senior manager R&D ingredients

Research manager - innovation center

Innovation manager – ingredients

Informal conversations & discussions with experts and employees of leading firms in the sector

Policy advisor - The Danish Agriculture & Food Council

Director - The Danish Agriculture & Food Council

Director - Food Science Park, Århus

Food sector analyst Professor - Denmark as a Food Valley 2012 Conference

Head of Section - Danish Ministry for Food and Agriculture

Member of the board – in leading firm case study 1

IT director in charge of supporting IT solutions for innovation projects – in leading firm case study 1

Communication director – in leading firm case study 1

Director of Organisational Development – in leading firm case study 2

Business Development Manager - – in leading firm case study 2

Professor at the biology faculty Copenhagen University – in leading firm case study 3

ANNEX 2 Interview question guide for second round of interviews

Square brackets indicate the aspect covered by the question relating to our assumptions (see section 2).

1. How has your engagement with Danish actors developed over the last ten years? [General]
2. While internationalizing innovation, have you established more/less research related relationships within Denmark? Why (not)? [Scope and size]
3. Who are your Danish innovation partners today? Have you engaged with new types of partners with internationalization of innovation? [Type of organizations]
4. If some of your previous partners have been abandoned, are they particular types of partners (actors/companies/organizations)? What was the reason? [Type of organizations]
5. Has the level of specialization of your partners in Denmark changed with internationalization of innovation in your company? More or less specialized? [content-specialization]
6. Which are the roles of Danish partners in the internationalization of innovation? Do they play a role in identifying foreign partners? Do they verify results of research carried out abroad? Do they help identifying new trends within your field? [content]
7. Have your Danish research partners internationalized as well? Do you need them to? [Scope and size]
8. Have you engaged with Danish partners outside the food industry? What are the trends in terms of cross-disciplinarity in your relationships with Danish actors? [content – disciplinarity]
9. How formalized are your innovation related partnerships? Do you make use of formal contracts, intellectual property rights protection etc.? Has this changed? [Formalization]
10. Are there any differences in the level of formalized relations between domestic and international research collaborators? Has this changed? [Formalization]
11. Have you experienced serious changes in your relations with Danish universities while you have internationalized innovation? In the financing of innovation activities? [scope and size]

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6 MNE'S INNOVATION STRATEGIES IN EMERGING MARKETS, THEIR INTEGRATION IN MNE'S GLOBAL INNOVATION NETWORKS & HOST INSTITUTIONAL FACTORS - A DYNAMIC PERSPECTIVE

Authors:

Vandana Ujjual*, Pari Patel and Nick von Tunzelmann (SPRU at University of Sussex, UoS, UK, participant no.14)

Abstract: This paper focusses on the innovation strategies of EU MNEs undertaken in Emerging Markets. It draws on case studies of 18 EU MNEs with R&D centres located in India, China and Brazil in the sectors: ICT, Automobiles, Pharmaceuticals and Biotechnology. The conceptual framework developed here identifies specific patterns and dynamics with respect to the innovation strategies undertaken at the R&D centre, and in its integration in the MNE's global innovation links (GIN). It was possible to distinguish 5 innovation strategies. These strategies are not mutually exclusive and fit on a continuum which displays increasing innovation capability, greater integration into the MNE's GIN and local embeddedness. Our results show that the R&D centre's innovation capability and strengthening of the host institutional frameworks have happened hand-in-hand. Further, the innovation strategies evolved based on the experiences of their interaction with different institituions in the host system of innovation. Despite the different ways in which they have evolved, a trend towards greater integration into the MNE's GIN and greater local embededdness is apparent. It also highlights distinctive features across sectors. By focussing on the specific factors (human resources, IPR, public institutes, market and competition), this paper contributes to our understanding of the role of institutional frameworks.

Keywords: Global Innovation Networks, Emerging Markets, Innovation Strategies, Host Institutional Factors.

*Corresponding author: Tel : +44 (0)1273 877262, email address: v.ujjual@sussex.ac.uk.

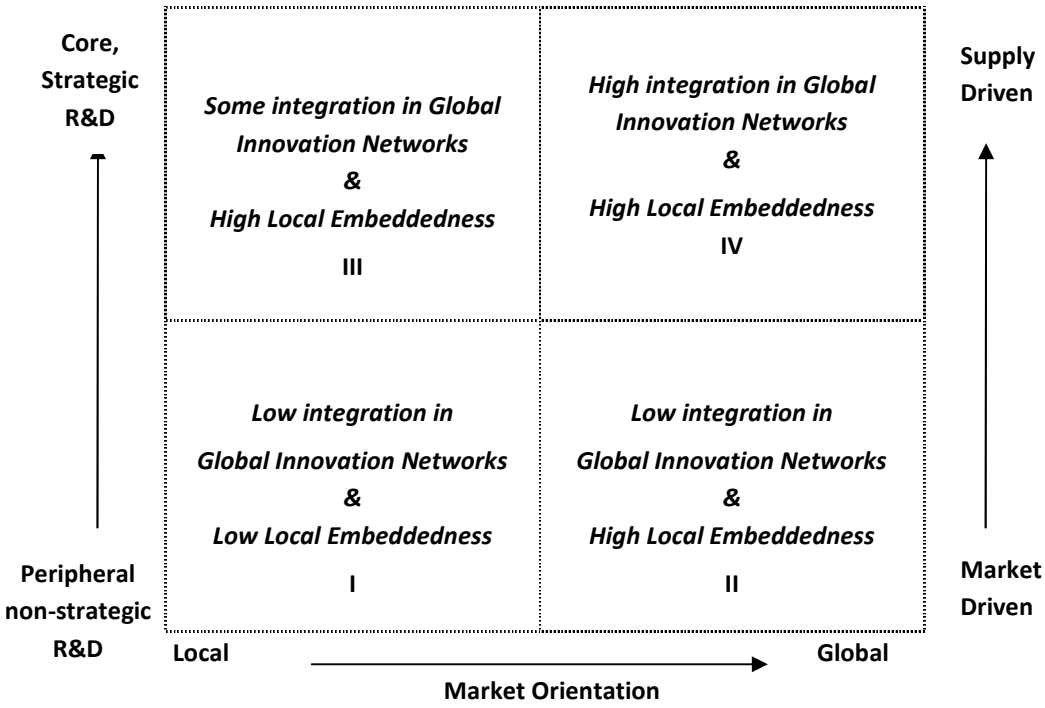
6.1 Introduction

This paper focuses on the knowledge creating activities of EU MNEs in Emerging Markets. The main aim is to improve our understanding of innovation strategies of firms with regard to their R&D facilities in Emerging Markets. We see such strategies as resulting from the dynamic interplay between the host institutional factors in which a centre is embedded and the extent of its integration in the MNE's global innovation networks (GIN). A further dynamic element is introduced by tracing the evolution in the kind of activities that are undertaken in the centre and in their market orientation over time. This paper is based on insights from case studies of R&D centres of 18 EU-based MNEs located in India, China and Brazil. These companies are amongst the leading R&D spenders in the following sectors: ICT, Automobiles, Pharmaceuticals and Biotechnology.

The conceptual framework presented in this paper attempts to identify the patterns and dynamics with respect to how the institutional strengths and weaknesses of Emerging countries interact with the innovation strategies undertaken at the R&D facility within these countries, the extent of their integration into global innovation networks and their local embededdness (see Figure 1 below). The underlying rationale is that a holistic approach is imperative in order to explain such innovation strategies. Such an approach has to take into account the host institutional determinants, the level of R&D capability at the R&D centre, and its market orientation. Further, we emphasise that any analytic perspective has to consider the interactions and the resulting synergies between these dimensions over time in order to provide a good understanding of the emerging patterns and dynamics with respect to the extent of integration in global innovation networks and the local embeddeddness.

Figure 1 presents our conceptual framework. The first point to note is that the extent of integration in the MNE's global innovation network and the extent of local embeddeddness are quite low if the local subsidiary undertakes peripheral and non-strategic routine type of R&D, mainly catering for the local market (cell 1). The figure also shows that the extent of integration in the MNE's global innovation network and the extent of local embeddeddness increases when the level of innovation capabilities of the R&D subsidiary is high and it has a global market orientation (cell IV). However, a greater integration in the global innovation network does not always coincide with the greater local embeddeddness, as is the case in cells II and III. The precise position of the R&D subsidiary in this diagram is influenced by the host region's supply factors such as the local technical/scientific skills and the competence of the supplier and science base. The relevance of market factors such as the local demand for low cost products and the flexibility in operations to meet those demands are also important, as are the internal demands from MNE's various business units. The host government incentives and national priority on undertaking certain kinds of technology development also have a role to play.

Figure 1: Innovation strategies at the R&D centres in host locations – a conceptual framework



The main distinctive feature is that the Figure 1 provides a framework to position the different innovation strategies pursued by MNEs at the R&D facilities in Emerging Markets, thereby it tries to capture the underlying dynamics in the interaction between the different dimensions effecting the pace and direction of globalisation of innovation. This framework has also enabled us to highlight any distinctive features across sectors, with respect to the innovations strategies of the R&D centres, the location specific institutional factors and in the characteristics of innovation networks.

The rest of the paper is structured as follows: Section 2 presents empirical background and contributions from the literature. Section 3 deals with the research methodology. Section 4 discusses the empirical evidence. In Section 4.1, it will analyse the different innovation strategies evidenced at the R&D facilities in Emerging Markets within the conceptual framework discussed above. Section 4.2 examines the specific host institutional frameworks that have influenced the MNE's innovation strategies in ICT, Automobiles, Pharmaceuticals and Biotechnology sectors. The paper contributes to the furthering our understanding of the role of institutional frameworks by focussing on the specific factors such as human resources, IPR regime, public institutes, market and competition. Section 4.3 provides insights into how the MNE's innovation strategies impact upon the host institutional factors. Section 5 concludes presents the main conclusions.

6.2 Institutional frameworks & its interaction with MNE's innovation strategies

Globalization of innovative activities in general, and R&D in particular, has increasingly become the centre of attention amongst policy makers and academics. It is not a new phenomenon as the

first major academic studies on the subject began appearing more than 20 years ago (for a summary of this early work see Granstrand et. al. (1992)). The main conclusion of this early work was that the world's largest R&D spending firms tend to locate a vast proportion of their innovative activities at home, close to the location of their headquarters (Patel and Pavitt, 1991; Gassmann, and von Zedtwitz, 1999). Past understanding of the globalisation of innovation activities stems from the analysis of two strategies for R&D FDI: the knowledge exploiting and knowledge augmenting strategies (Patel and Vega, 1999; Dunning and Narula, 1995; Kuemmerle, 1996*)*. These strategies have been analysed as a function of different levels of technology capabilities of the MNEs, its home country and the host country. These studies have noted the strong influence of national innovation systems on the technological and innovation activities of MNEs (Pavitt and Patel, 1999; Patel and Vega, 1999; Le Bas and Sierra, 2002).

In general, the knowledge augmenting (or sometime referred to as the home based augmenting) strategies are associated with locations in advanced countries, where the primary motivation is to tap into the science and technology base in foreign centres of excellence. The underlying rationale is that MNEs internationalise R&D to monitor new technological developments and generate new technologies and products from locations abroad (Cantwel, 1995; Kuemmerle, 1997). Such activities are concentrated in the few locations that can provide the advanced resources and institutions and that display continued commitment to improving their technological competitiveness position (Jones & Teegen, 2003). This literature suggests that the 'parent corporation continues to serve as the most active creator and diffuser of knowledge within the corporation' (Gupta and Govindarajan, 2000, p. 490).

However, when it comes to discussing the capabilities in Emerging Markets, the literature has largely centred around the exploitation of existing technology developed at the home base (Dunning and Narula, 1995; Kuemmerle, 1999; Ernst, 2002; UNCTAD, 2006). Part of this argument rests on the premise that emerging countries such as India and China are characterised by weaker IPR compared to advanced economies, hence the R&D activities of foreign MNEs undertaken in subsidiaries tend to be different from the activities undertaken at home. Despite the weaker IPR regimes some of the most innovative MNEs are increasingly setting up foreign R&D affiliates in these countries. In trying to explain this, 'UNCTAD and OECD studies have found that these R&D activities often focus on developing technologies that typically need to be used in combination with other complementary technologies. In the absence of the latter, local technology leakage does not pose a major threat' (OECD, 2008, p.45). Empirical evidence from China suggests that that strong internal linkages among technologies can allow firms to generate value from their overseas R&D even in the absence of strong IPR protection (Zhao, 2006). Studies show that provided that the R&D centres are wholly-owned, they are able to protect knowledge and prevent unwanted technology transfer, as the tendency for full ownership is positively related to the technological sensitiveness of MNE's business field (Gassmann and Han, 2004; China S&T Statistics, 2003). Many innovative ICT firms in the San Francisco Bay Area follow a hybrid model, utilizing both their own R&D centres particularly where intellectual property is a concern and extensive partnerships with one or more Indian majors.

Based on the studies that have focussed on the R&D internationalisation in Emerging Markets, it can be said that in general there is a lack of consensus in the literature with respect to the kind of R&D activities that the firms internationalise in such countries. One view is that innovation activities in foreign R&D centres are only concerned with local product adaptation through intensive cooperation with customers and suppliers. Previous empirical evidence has suggested that a large part of MNE's R&D activities in China is market driven and development oriented rather

than research oriented. For example two-thirds of MNE's R&D alliances in China between 1995 and 2000 are development oriented (Li and Zhong, 2003). Further studies have argued that the likelihood of establishing a local development unit increases if a given firm's business requires local product adaptation and intensive customer cooperation (von Zedtwitz and Gassmann, 2002). Another view is that innovation activity of MNE's can best be described as global generation of innovations, i.e., innovations are conceived on a global scale from the moment of inception in an inter-play between R&D and innovative activities in both the home and the host countries (Archibugi and Iammarino, 2002). This is partially supported by cases of US companies such as Cisco and Intel. Cisco's second global headquarters is setup in Bangalore to leverage India's engineering resources and develop products for Indian and other emerging economy markets. In the case of Intel, product development accounts for 65% of activity in India and has recently begun designing products in India aimed at developing country markets.

The vast literature has provided us with a clear understanding that the precise features of a host country needed to attract R&D depend on the industry and activity involved (UNCTAD, 2005). However, identifying the precise features that are present in healthy institutional environments is a challenge. Even harder is the task to specify the genesis and underpinnings of healthy institutions (Mudambi and Navarra, 2002). Evidence based on the foreign R&D activities of US MNCs found that country-level investments that support institutions conducive to economic development and scientific output generate a munificent environment for R&D (Doh et al., 2005). Further, political stability with low risk of change, low corruption and IP rights protection were important as well. The increasing role displayed by R&D affiliates located in a host country in the generation of new technology is in accordance with the comparative advantage in innovation of that country (Papanastassiou and Pearce, 1997; Cantwell, 1995). Both the availability of scientists, technologists and engineers and the future human resource capabilities are important factor in the location decision (Taggart, 1991; Voelker and Stead, 1999). Higher educational system is seen to be a major factor (Papanastassiou, 1997; Kuemmerle, 1999).

The drawing power of institutions is shown to be highly contextual (Dunning and Zhang, 2008). In new technology industries, the availability of R&D personnel and low costs of doing R&D in India have been identified as the primary drivers, whereas in conventional technology industries the primary factor is proximity to manufacturing and to the Indian market (Reddy, 2000). In certain sectors such as Pharmaceuticals there is a greater role for public research institutes engaged in basic research. The relevance of an efficient IPR system is also critical for this sector. In general, IP protection is more relevant for asset augmenting FDI strategies compared to efficiency seeking FDI strategies where fiscal incentives are rather more relevant. However, it is shown that for latecomer countries, copying and reverse engineering have historically been a vital source of learning and upgrading (Lall, 2003).

Governments are shown to have a twofold influence. They primarily affect the climate for innovation and the local linkages between science and technology in the host country. They also initiate specific policy measures that have an influence on the upgrading of the R&D activities of the affiliates. But such specific investment incentives have only an incremental rather than primary effect on R&D locations (Cantwell and Mudambi, 2000). An empirical study comparing the R&D collaboration with public knowledge institutions in small advanced economies finds that Finland has a relatively high share of innovating firms involved in such R&D compared to Netherlands (van Beers et al., 2008). This they attribute to Finnish policy-induced collaborations, linking innovating firms to domestic public knowledge institutional structure more effectively than Dutch innovation

policies. In the Netherlands the focus of policies is more on financial instruments like tax credits that address firm's production costs than on improving collaboration (van Beers et al., 2008).

6.3 Data gathering and methodology

The empirical evidence is gathered from case studies of the innovation activities of 18 EU-based MNEs with R&D facilities in India, China and Brazil. These MNEs belong to the following sectors: ICT, Automobiles, Pharmaceuticals and Biotechnology. The selection of the EU MNEs was based on the fact that they were amongst the leading players in their respective sectors both in terms of market share and in terms of being large employers in their home countries. They are also amongst the leading R&D spenders in the EU. Another criterion for selection was whether the MNE had established R&D and innovation activities in the India, China and Brazil.

The data gathering was facilitated by means of semi-structured interviews undertaken at the R&D centres of the EU MNEs in India, China and Brazil. In total 27 interviews were undertaken between March 2010 and February 2011. The person interviewed was the head of R&D centre. A four page structured questionnaire comprising 23 questions was used as an interview guideline. There are 4 sections in the questionnaire, the first of which captures information about the R&D in the company as a whole. The second and third sections are devoted to the activities of the R&D Centre and on it external links, respectively. The centre's structure and relationship with HQ and other R&D centres of the company are captured in the final section. The instrument was constructed in such a way that the template for interview guidelines used at the Indian R&D facility could be used in China and Brazil with only minor modifications.

The empirical evidence gathered provides important insights into the changes in the agenda of the R&D centre in the host location over time. As well as providing comparable data on MNE's R&D activities from a host institutional perspective. The initial strategy was to undertake interviews for each MNE in at least two Emerging Markets, mostly India and China. However, this proved to be too difficult as shown in Table 1. For example in the case of Infineon and ST Microelectronics it was only possible to interview the head of R&D centre in India. In relation to the ICT MNEs we were able to secure 2 interviews in different locations in 4 out of 6 firms. However, for the Pharmaceuticals (including 2 biotechnology firms) this was possible for only 3 out of 7 companies and in the case of Automotive industry 2 out of 5.

Table 1: MNEs interviewed at R&D centres in emerging markets

	India	**China**	**Brazil**
ICT			
NSN	y	y	n
Philips	y	y	n
Ericsson	y	y	n
Alcatel	y	y	n
ST Microelectronics	y	n	n
Infineon	y	n	n
Pharmaceuticals & Biotechnology			
AstraZeneca	y	y	n

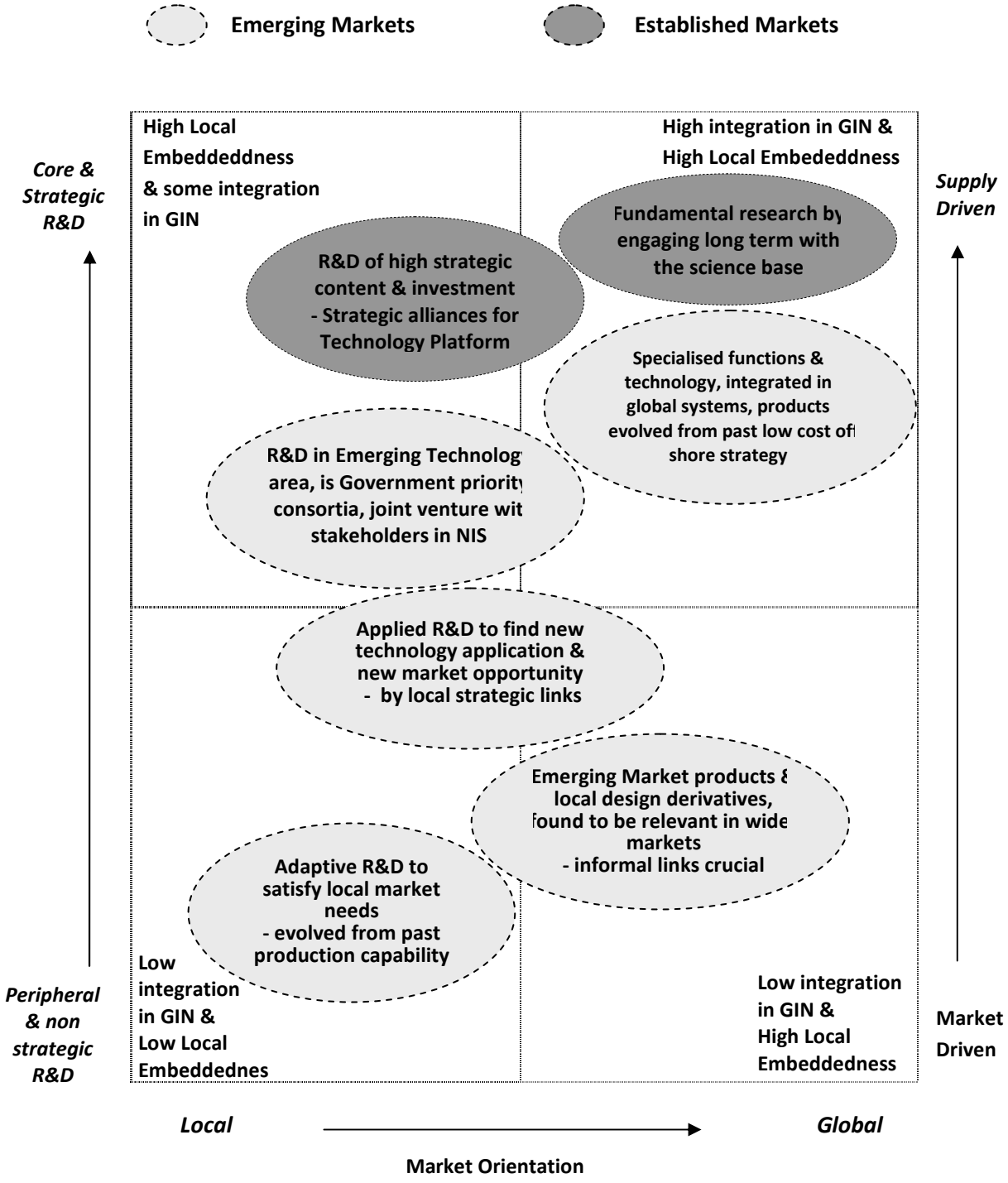
GSK	y	y	n
Sanofi Aventis	y	n	n
Novartis	n	y	n
NovoNordisk	n	y	n
Novozymes	y	y	n
Danisco	n	y	n
Automobile and Parts			
Volvo	y	n	n
Bosch	y	n	y
Continental	y	y	n
Fiat	n	n	y
Autoliv	n	y	n
Total			
18 MNEs	13	12	2

6.4 Discussion

Our results show that the EU MNEs in general regardless of the sectors they belong to, resort to multiple innovation strategies simultaneously at their host locations in Emerging Markets. Hence to regard innovation activities undertaken at the Design Centres, R&D centres, Technical centres, and Centres of Excellence located in the Emerging Markets as pure development activities would be ill conceived. While the innovation capabilities of all these centres transcend the low level, peripheral kind of tasks, they have not yet advanced to the level of fundamental research or core R&D with high strategic content. For example in our case studies the generation of common technology platforms for the entire company, research into new materials that can potentially generate high value and strong IPs, and other critical functions involving substantially high investments are mostly confined to the home country locations of the MNEs and do not feature in the innovation activities undertaken at any of these centres.

Drawing on the insights from the MNE's innovation activities in host locations, it was possible to distinguish 7 innovation strategies by analysing the level of innovation and the degree of market orientation, within a host institutional context. As shown in the Figure 2, these innovation strategies fit on a continuum which displays increasing innovation capability and greater integration into the MNE's global innovation networks and local embeddedness. Out of the possible 7 innovation strategies identified, only 5 innovation strategies featured at the Emerging Market R&D facilities in our sample. These innovation strategies are not mutually exclusive, as is explained in the sections below. Some R&D facilities simultaneously pursue a number of these innovation strategies. Since the focus of the paper is on the innovation activities of the EU MNEs in Emerging Markets, the rest of the discussion will concentrate on the 5 innovation strategies identified in Emerging Markets.

Figure 2: Dynamics in the interaction between the: innovation strategies of R&D centre in host location, institutional factors in host location in which it is embedded & extent of integration in MNE's global innovation networks



6.4.1 Analysing the Different Innovation Strategies at the R&D Centres in Emerging Markets

Based on the conceptual framework outlined earlier, it was possible to identify specific patterns and dynamics of innovation strategies an R&D centre and its integration in the MNE's global innovation links in the context of the host institutional factors. At one extreme is the *Adaptive R&D* strategy that is strictly market driven and where R&D is mainly exploitative, where there is low level of integration in global innovation networks. At the other end is the strategy involving supply driven and explorative R&D, which relies on *Specialised technology capabilities* that are part of a system and which are integrated in global products and solutions. In between these two extreme are three further R&D strategies: the *R&D on Emerging Market products and technology*; the *Applied R&D for the generation of new technology applications and to find new market opportunities*; and the R&D on *Emerging Technology area that are government priority in the host country*.

Figure 2 manifests a varying degree of local embeddedness across the five types of MNE strategies as a function of the strength and weakness of the host institutions in the local system of innovation. In relation to the *Adaptive R&D* strategy, the activities are mostly undertaken internally and local links, which are mainly with the suppliers and customers, are weak. In this case the local supplier links are mostly outsourcing relationships introduced as a cost-saving measure and the customer links are mainly to get the market input and customer feedback. In the intermediate strategies, there is greater embeddedness in the local networks. For the R&D on *Emerging Technology area that is government priority of host country* and in the case of *Applied R&D*, the local partner inputs are critical. Here the R&D facilities are involved in formal long-term collaborations, joint projects, joint ventures, and research consortia. For the R&D strategy to come up with *Emerging Market products and technology*, the local informal links are important as well.

Our case studies show that the specific innovation strategies pursued depends on the kind of opportunities and the various operational and managerial difficulties arising from the institutional strengths and weakness in the host system of innovation. As shown in Figure 2, the five strategies lie on a continuum with respect to the relevance of supply driven and market driven institutional factors. For example, the centres with *Specialised technology capabilities* are part of a system and hence integrated in global products and solutions. They are primarily skills driven and engage in upgrading their innovation capabilities, through in-house training to develop specialised expertise and provide external training to local universities. The emphasis is also on developing various ways to integrate the specialised functions and technologies in the global systems, products and soutions.

On the other hand, in the case of *Adaptive R&D* the centres are purely market-driven. This is the case for Ericsson China R&D Institute, where the localisation of existing products and technologies to meet the demands for emerging countries has been high on the agenda. Almost all (90%) of the operations at this centre are to cater for local specific requirements that are very different from those of the markets in the developed countries. In such market driven centres the most pertinent capabilities are those related to undertaking advanced development in-house as well as networking to foster local collaboration with providers of such capabilities. The *Applied R&D* strategy equally emphasises creative ways to open up new market opportunities, signaling that demand considerations are becoming more important over time reflecting the prospects of large and growing markets. Undertaking innovation activity near the market is considered essential to translate the distinct local demand in concise form, and to provide alternative technology solutions in the wake of specific technology constraints and regulatory requirements.

While in the case of centres engaged in *R&D in Emerging Technology areas that have been identified as government priority in host location,* the institutional factor most relevant is the

government support. The emphasis is on mobilising local networks and setting up of research consortia in order to help establish an institutional infrastructure in the host system of innovation that is conducive for such activities. This is evidenced from the research undertaken by Fiat and Bosch on flexi-fuel technologies in Brazil, Novozymes on second generation bio-fuel for the Chinese market, Astrazeneca involved in neurosciences research in China, and development of local mobile technology standards in the case of NSN in China.

Evolution of the Innovation Strategies and their Integration in MNE's GIN

The 5 different innovation strategies identified are not static, but evolve in relation to the MNEs previous engagement in the host market, and are based on experiences of their interaction with different institituions in the host system of innovation. Some facilities have engaged over a long period in the host location and have been involved in continuously upgrading the capability at the R&D facility. This is because their initial strategy was solely determined by the availability of low cost skills rather than on accessing advanced specialised competences. These centres have now accumulated specialised technology capabilities, with some attaining the status of an excellence centre which are recognised by the entire organisation. This is the case of most ICT R&D centres with system integration capabilities, the Auto R&D centers undertaking automotive engineering services in Emerging markets and the specialised centres for Biotechnology such as those specialising in protein engineering capabilities.

The search for global efficiency has driven the concentration of these specialised functions to a single location thereby reducing duplication. These centres do not cater for local demand but contribute to the parent company's global product development. For example, the STMicroelectronics set up a design centre in India in 1995 which initially undertook characterization, design layout, work on libraries etc. As the workforce became more experienced, the centre has advanced to designing full chips and complete systems (set top boxes). As a consequence 15% of all VLSI design and software activities at STMicroelectronics were carried out in India in 2007, making it the largest design centre outside Europe contributing to one of its lead technologies. This process is also evidenced in a number of Auto R&D centres. For example when the Bosch centre in India (Robert Bosch Engineering and Business Solutions) was setup it only undertook embedded software development but it gradually moved up the value chain so that today its activities encompass complete product design i.e., electronic design, hardware design, software design and integration.

In certain other cases the evolution was a gradual one, from being a support centre for local production activities to undertaking adaptive R&D, to being fully responsible for developing certain Emerging Market products and innovation with a global mandate. The Infineon Design centre in Bangalore was set up in 1997 as essentially a resource augmentation centre. Over the years it has consolidated its position in the company by acquiring greater knowledge and getting more involved in the product roadmap and project management. Recently, the centre has advanced further by assuming complete product development responsibilities, involving the management of global teams.

Some centres are involved in simultaneously developing products for the Emerging Markets and undertaking specialised functions for the company as a whole. This is seen in our Biotechnolgy and Pharmaceutical MNEs (Novozymes and AstraZeneca centres in India), in ICT (Alactel centre in India, the Philips centre in China) and in Auto (Bosch centre in India). To illustrate, the Volvo centre in India is developing products for the emerging markets at the same time as providing

specialised software and engineering functions for the company's other business areas. The centre has gradually evolved from a strategy based on local supplier sourcing and purchasing to developing Emerging Markets products.

In some cases, the local R&D facilities have evolved from simply monitoring local technology trends to undertaking Applied R&D. Over time, the significance of engaging in local and global networks in order to open up new market opportunities became apparent to the managers of such R&D centres. Thus, they have begun to engage with a broader base of potential clients in order to identify new applications based on existing technology. The R&D activities of Ericsson and NSN in China and that of Philips in India provide examples from ICT sector. Similar activities are evidenced in Auto manufacture (Fiat) and Auto component supplier activities (Bosch) in Brazil. In Biotechnology, MNEs aims to develop new application of enzymes in sectors beyond food and agriculture. For this the local collaboration is with global players producing rubber products, textiles, detergents etc.

The discussion above highlights the fact that in most cases that strategies have followed an evolutionary path. However, there are exceptions where a company has pursued a more opportunistic strategy. For example, the R&D capability at Novozymes site in India was rapidly upgraded by acquiring complimentary expertise and specialised technology knowledge in surface enzymes, and is now the centre of excellence for wine and juice enzymes R&D.

This can also be said about the extent of the integration of different R&D centres into the MNE's global innovation networks. There are a variety of ways in which such integration take place. In certain cases it has followed an evolutionary trajectory, where the integration was gradual, from being loosely engaged in production networks into a greater integration in the global innovation networks of the parent company, in line with the accumulation of innovation capabilities at the R&D centre over many years. Whereas, in other cases, the integration was more rapid, resulting from the acquisition of local companies with specialised capabilities that are complimentary to the strengths at home.

General Findings based on the Analysis of the 5 Innovation Strategies

Despite the different ways in which the 5 innovation strategies have evolved, a trend towards greater integration into the parent global innovation network and a greater degree of local embededdness is clearly apparent on analysing the 5 innovation strategies in Emerging Markets. The Bosch case illustrates this. Being a global Auto component supplier, Bosch has R&D facilities in lead markets by following its customers, the global Auto manufacturers with aggressive expansion plans in high growth markets. The activities undertaken at its Development centre in Brazil focuses on developing local products such as fuel systems (diesel, gasoline and ethanol), brake systems and chassis and automotive electronics. The centre also contributes to the development of flex-fuel engines, which use ethanol as fuel and hence has become a competence centre in flex-fuel technology and the World Engineering Centre for specific products. Internal links with the parent and the interaction with global engineering development teams played a crucial role in enhancing the local innovation capabilities, so are its external links with local engineering teams of the manufacturers like Fiat, for upgrading its capabilities.

The strategic factors in host Emerging countries for undertaking R&D includes the availability of skills, market, presence of research institutes, and government-led initiatives, confirming past research (Demirbag and Glaister, 2010). However, a combination of these market-driven and supply-driven factors are relevant for the intermediate innovation strategies in our framework. Only

the two extreme innovation strategies are driven by strategic factors such as market and skills alone. In our Pharmaceutical sample for example, the strategic motives for pursuing the innovation strategies at the R&D centres in India and China are driven by the need to access advanced level skills and scientific expertise in specific therapeutic areas, to develop drugs closer to the market and to take advantage of the government initiatives in areas of priority (diabetic research and TB). Further, cost is not seen to be that important. However, cost seems to matter for the functions outsourced to Contract Research Organizations (CRO). The discussion below focuses on these institutional factors with the aim of highlighting any sectoral differences.

6.4.2 Institutional Factors and Sectoral Differences

Human Resources

The availability of large pool of well-qualified scientists and engineers is one of the key factors. In ICT and Auto, the MNEs looking to expand and scale up the engineering and other specialised functions in the medium to long term, are able to create the critical mass. For example, NSN's R&D facility in China grew from under 500 staff to 3000 staff in just 3 years. The host locations also offer the flexibility of operations. EU MNEs in our sample looking to deal with the peaks and troughs of the business cycle, was able to rapidly upscale and downscale their activities by outsourcing to local specialised technology and service providers. For example, the Continental centre in India has developed strong linkages with local suppliers of software services. Pharma MNEs also establish linkages with local CRO to undertake clinical development, and in-license from service providers. In the case of India this is due to the strong heritage in the production of generic drugs and the highly advanced skills base in Chemistry.

Despite this, MNEs face many challenges such as the disparity in the quality of the skills, retention of key personnel, investing heavily in upgrading the capabilities and to overcome the cultural differences. The recruitment of experienced mangers for more important roles such as to lead and manage projects, is a severe challenge across all sectors. Most MNEs try and overcome this by recruiting a growing number of expatriates (scientists in senior roles) returning home. For example, the AstraZeneca and Novo Nordisk R&D centres in China employ a similar strategy of recruiting Chinese scientists who are expatriates.

However, some of the challenges are much more critical in specific sectors. The retention of skills is a greater challenge at the R&D centres in ICT and Biotechnology, compared to Pharma and Auto. Whereas, it is much harder to find skilled people for specific functions in Auto. The Continental R&D centre head in India found it difficult to recruit people with a good understanding of the combustion process in a cylinder of an engine, which is essential when developing car engines.

"In India...there is Tata and Mahindra and few others but it's not comparable to what is done in Europe or the US today. And so the number of experts for real combustion process, exhausts, after treatment process, they are not there. So the core development is initiated in Europe or in the United States ... then our Indian team is either supporting the core development, or applying it now to Tata and other projects locally."

IPR Regime

MNEs employ many ways to overcome the threat from weaker IP protection at their R&D centres in India and China. Generally, the innovation activities that are critical for the competitiveness of the company are undertaken in-house. It is the non-core and support functions that are outsourced to specialised technology suppliers & service providers. Furthermore, most of the local collaborative projects on emerging technology areas involve pre-competitive research. However, the weak IP regime is stalling the progress in upgrading the innovation of the R&D centre only in some cases. MNEs across sectors approach this differently depending on the extent of the threat of weak IP regime. For example, Novozymes found the retention of key skills a greater challenge than the retention of its formal and informal IP in India.

Public Research Institutes

The cooperation with universities and research institutes is regarded as an important means to access the complementary technology and resources. Despite this there are differences in the underlying motives for collaboration across the sectors. In the ICT sector, the university links are primarily to ensure a steady supply of engineering skills. Whereas, in the case of Biotechnology and Pharmaceutical sectors, the emphasis is on connecting with developments in basic research. In the Auto sector, the local linkages are mostly with suppliers (in the case of Auto manufacturers) and customers (in the case of Auto suppliers).

In the ICT sector, some centres have research collaboration with premier institutes in field of computer science and networking. This is the case of Alcatel's research facility in India. Similarly, ST Microlelectronics centre has dedicated laboratories at premier research institutes such as India Institute of Science (IISc) and India Institute of Technology (IIT). In Ericsson's centre in China the university collaborations involve sponsoring of research projects at the universities . Whereas, in most other cases it is to source talent as seen for Ericsson's centre in India.

More long term and extensive research collaborations are evident in the case of Pharma R&D centres in China. NovoNordisk has set up a research foundation with Chinese Academy of Sciences to undertake research in diabetes, bio pharmaceuticals and protein sciences. In the case of GSK, the centre's collaboration program on combinational chemistry with the Shanghai Institute of Material Medical has been ongoing for more than ten years. AstraZeneca centre has alliances with Beijing Medical School on basic science. It has also established technical collaborations by investing in local bio-companies. There is evidence of such links in Biotechnology as well. According to the biotech MNE's R&D manager in China,

"In addition to having access to highly educated staff and first class universities, we also find a mature biotechnology network in China, which we can use to continually enhance our advantages in the field of enzyme discovery and protein engineering"

Markets and Competition

For the MNEs in our sample, the emerging economies provides great market opportunities due to the high growth in domestic demand and escalating income level. In order to tap into the rural and low-income market segment that are at the bottom of the pyramid, the MNEs in the business of mobile technology and services perceives immense potential in developing socially applicable applications such as emergency services, tele-medicines, e-learning, micro-finance. The

development of these applications is by partnering with the domestic informal institutions who closely engages with this segment of the population.

Another driving factor is the development of local standards in these markets. The MNEs in the business of wireless and wire line technology infrastructure, finds it important to collaborate with the telecom operators and service providers. The Bell Labs facility in India partners closely with Alcatel-Lucent customers as they deploy new technologies such as cellular data and low-cost networking to address their most challenging problems. The Alcatel facility in China collaborates with major telecoms operators such China Telecom and China Mobile.

However, the sales prospects in the market need to be large enough to justify the R&D activities in host locations. Alcatel undertakes extensive localisation at their R&D centre in China unlike in India. According to the R&D manger,

'*India is still not a major customer for ALU, in comparison to China. Installations in India are 2G. There are teams that support the legacy installations (such as the E10 switches). Focus on India is on voice, the 3G licenses have not been given out by the Government, whereas, China is already 4G and by virtue of being a major customer also has a much bigger R&D.*'

This is the case with Novozymes, where its R&D centres are set up only in markets with sales potential. The two Biotechnology MNEs supplies enzymes and other bio-ingredients to global players. The localisation needs of their international customers are the main reason for undertaking local R&D.

A number of Auto R&D centres are catering for the demand for low cost products and technologies, by undertaking localisation of existing products and technologies involving re-engineering, cheaper design implementations and other adaptations. The Autoliv facility in India plays a critical role in its overall effort to improve safety for small cars, while the Fiat centre in Brazil undertakes R&D to cater for the specific demands for the flexi-fuel and locker technologies in automobiles. The rationale was that the differential local unique demands on products, such as smaller engine for smaller cars, could not be easily met by the high specification products used in high-end cars that are available for the EU market.

The Auto component suppliers such as Autoliv and Continental, established R&D centres in China mainly to be present in one of the largest automotive markets in the world, close to the growing R&D presence of major international car manufacturers in that location. This is also the driver of Bosch centre in Brazil. Further, the Auto MNE responds to demands from the local OEMs for rapid solutions to the problems encountered in production engineering. Additionally, when the centres were set up, the Indian market was of little importance to Auto component suppliers, but recently supplying the Indian OEMs has increased in importance. Hence, in Continental, certain business units have started to collaborate and to provide consultancy services to local auto manufacturers such as Mahindra and Tata

6.4.3 Impact of MNE Innovation Strategies upon Host Institutions in the Host System of Innovation

In many of our cases, the innovation strategies have impacted upon the institutional frameworks in host Emerging countries, where the MNE's subsidiary innovation agenda and the strengthening of certain aspects of the host institutional frameworks have happened hand-in-hand. Though the weakness of the institutions in these host innovation system poses a constant risk to MNEs trying to

increase the scale and scope of innovation activities in the Emerging Markets, the cases demonstrate their direct engagement in strengthening the institutional shortcomings. Some of the role played by these facilities include:

- Devising specialised courses at universities to fill the gap existing in the demand and supply for appropriate skills for specialised functions in the labour market;
- Encouraging entrepreneurial activity internally, normally transcending the company boundaries and spilling over into the market benefiting the local innovation system. This involves activities such as technology-based spin-offs that are no longer core to the company, option-based alliances with local specialised technology providers, and expertise offered through consultancy business.
- Transferring best industry practices to its outsourced relationships;
- Developing the local supplier base to cater for the MNE's local as well as global markets has resulted in world class and highly competitive supplier capabilities;
- The bridging role played by key personnel at these facilities where they advise the government and other stakeholders on setting up industry regulations and technology standards in emerging areas of mutual interest.

6.5 Conclusions

This paper draws on the insights from case studies of innovation activities of EU MNEs undertaken at their R&D subsidiaries in Emerging Markets of India, China and Brazil. It set out to examine the dynamics in the interplay between the three dimensions determining the pace and direction of globalisation of innovation, *vis.*, the innovation strategies undertaken at MNE's R&D facilities in Emerging Markets, the host institutional factors in which the centre is embedded, and the extent of its integration in the MNE's global innovation networks. The conceptual framework developed in this paper uses a dynamic approach and takes into consideration the interactions and the resulting synergies between these dimensions over time.

Based on the new empirical evidence gathered, five different innovation strategies were identified in Emerging Markets depending on the innovation capabilities of the R&D centre and its market orientation, within a host institutional framework. These strategies are not mutually exclusive and lies on continuum of increasing innovation capability, wider market orientation, greater integration into the MNE's global innovation networks and local embeddedness. This enabled us to provide a good understanding of the emerging patterns and dynamics with respect to the extent of integration in global innovation networks and the local embeddeddness.

Our results show that despite the different ways in which these innovation strategies have evolved, a trend towards greater integration into the MNE's global innovation network and a greater degree of local embededdness is clearly apparent. The distinctive features across sectors, with respect to the innovations strategies of the R&D centres, the location specific institutional factors and in the characteristics of innovation networks are highlighted. By focussing on the specific factors such as human resources, IPR regime, public institutes, market and competition, this paper contributes to our understanding of the role of institutional frameworks. It shows that in Emerging Markets the R&D centre's innovation agenda and the strengthening of certain aspects of the host institutional frameworks have happened hand-in-hand.

The results of the paper has important implications for the EU MNEs and for organisations involved in the creation, use and diffusion of innovation. The globally networked nature of innovation means that it has implications for organisations from both developed and developing countries engaged in attempting to integrate the widely dispersed international innovation networks. By considering the specific comparative advantages and innovation strategies in India, China and Brazil, it has highlighted the policy areas that need to be addressed to strengthen the institutional framework for fostering innovation with the involvement of MNEs.

Firstly, the MNEs involved in new technology based products and processes innovation require knowledge inputs from multiple fields. It is important to mobilise both market-related inputs as well as specialised technical knowledge in order to successfully innovate. It is become evident that such new and complimentary knowledge are increasingly being sourced from Emerging Markets, residing within various informal and formal institutions in the host NIS.

Secondly, in industries characterised by compressed product life cycles and increasing speed to market, as well as in the industries facing market saturation in established economies, the high growth markets in India, China, Brazil etc. are very attractive. In these locations however, it is required to undertake innovations that are different from the innovations undertaken at home (and in established markets) to succeed in these markets. In order to undertake R&D on Emerging Markets products and technology, the institutional strengths at home locations and the existing research facilities in Europe and the US are increasingly found to be unsuitable and out of touch with the specific knowledge requirements and the essential market feedback.

In the R&D facilities in Emerging Markets, such research can be undertaken in close interaction with the market and can facilitate frequent exchanges with the key stakeholders involved in the development of the technology and innovative solutions. Moreover, the conditions are most suitable for enabling them to simultaneously introduce the resulting innovations in all other markets if it is found relevant. The countries such as India and China combine enormous market potential with a large pool of well-qualified scientists and engineers. One specific location advantage is that it is able to provide the flexibility, which is important to undertake innovation activities efficiently and to sustain higher returns to R&D investments.

In recent years the MNEs have focussed on developing low cost products in Emerging markets as a competitive strategy rather than competing with the expensive and ill-adapted European products. The attractiveness of vast and untapped market potential combined with the presence of essential elements in the host innovation system conductive for undertaking R&D have encouraged MNEs to do applied R&D to find new technology applications and to create new market opportunities. The presence of large international suppliers and customers, premier research institutes with world-wide recognition, presence of low cost service providers, system integrators, contract research organisations, as well as the presence of specialised technology and service providers in the region have been the main factors.

Moreover, the government in these countries has recently priotorised key emerging technology areas as a means to increase the competitiveness of national industries. This provides the EU MNEs, an opportunity to contribute not just in technology development by benefiting from the public funding and support, but also in establishing appropriate industry regulations and technology standards and in strengthening the institutional framework for undertaking innovative activities in general. The latter is imperative for MNEs pursuing an Emerging Market innovation strategy as a means to have the competitive edge and to succeed in a toughening global competition.

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7 INSTITUTIONAL VOIDS AS A TRIGGER FOR THE EMERGENCE OF GLOBAL INNOVATION NETWORKS: THE CASE OF DIGITAL SERVICE FIRMS

Authors:

Helena Barnard* (GIBS at University of Pretoria, UP, South Africa, participant no.12)

Tarmo Kalvet and Marek Tiits (Istitute of Baltic Studies, IBS, Estonia, participant no.5)

Abstract: The existing literature on the globalisation of innovation is dominated by work on advanced multinational corporations from the developed world. But how do firms from institutionally underdeveloped environments become not only part of, but also the initiators of global innovation networks? It is well known that "institutional voids" in developing countries, i.e. the absence of elements such as well-developed and well-regulated customer and financial markets, a logistics and distribution infrastructure, and an enabling regulatory context, may limit economic activity. We argue that the very institutional voids that may be seen to be potentially limiting are actually triggers for the emergence of global innovation networks.

We study this process by comparing two cases, Skype from Estonia and MXIT from South Africa. Multiple interviews were conducted at each of the firms, and supplemented with archival data. We conclude that firms selling digital services operate in a globally dispersed way and use the world as a reference point when considering both what constitutes a market and its boundaries, and think similarly about the acquisition of capabilities and suppliers. As firms rely on the vision of few founders and on a global (rather than local) network, they do not need systemic engagement with the home country. But even though the international orientation of these firms is as high, the sourcing of capabilities is not as often done through subsidiaries.

Keywords: Institutional Void; Global Innovation Network; Skype; MXIT; Capacities; Alliances.

*Corresponding author: Tel. +27 11 771 4000/4213, email address: barnardh@gibs.co.za

7.1 Introduction

How do firms from institutionally underdeveloped environments become not only part of, but also the initiators of global innovation networks? Increasingly, firms like Huawei (from China) and Wipro and Infosys (from India) are becoming formidable competitors globally with extensive networks through which market their offerings and also innovate – even though their home countries are not technological leaders. In this paper, we hypothesize that the local factor conditions that may be seem to potentially limit the formation of global innovation networks are actually triggers for the emergence of such networks.

There is currently only limited empirical evidence of the emergence of global innovation networks, and most of the available work is on advanced multinational corporations (MNCs) from the developed world (e.g. Archibugi and Michie 1995; Cantwell, 1989; Cantwell & Piscitello, 2007; Chesbrough, 2006), although some recent contributions analyse the impact of the globalisation of innovation on small and medium sized companies (Bianchi et al., 2010; Van de Vrande et al., 2009). There is increasingly anecdotal evidence that firms create and operate through global innovation networks even when they originate from countries where the pool of human resources as well as research and development (R&D) capabilities are limited. But little is understood about the emergence of global innovation networks in firms from less developed countries.

The emergence of firms that sell digital services to a global market is a new phenomenon, and challenges many of the established insights of international business research. For example, the essence of the Uppsala internationalization theory (both the original and updated version) is that firms increase their exposure and commitment to a foreign market (or supplier base) incrementally, as they increase their understanding and trust of those markets and suppliers (Johanson and Vahlne, 1977; 2009). But what do those terms mean for a firm like ChessCube[1], an online chess platform with 1.4 million users globally 40 months after founding, or Clickatell[2], a mobile messaging provider that delivers SMS text messages on behalf of bulk senders to 221 countries through 871 network operators? Terms like "commitment" and "internationalisation" can perhaps be used at the most general level of analysis, but it may be more appropriate to extend existing theory to better account for those firms' relationship with their country of founding and the wider world[3].

We study the emergence of globally connected innovative firms from less developed countries by comparing two cases, Skype from Estonia and MXIT from South Africa. The choice of countries is deliberate, as the majority of developing countries lack the scale of India and China. Both firms sell digital services to end users in a global market, although the firms are very different in size. According to Wikipedia estimates[4]Skype has more than 663 million user accounts, and MXIT 27 million (growing at a rate of 40,000 new subscriptions a day and thus following a similar growth pattern). Indeed, the user base of both is a moving target. Both firms are highly internationalised, but not structured as traditional multinationals with subsidiaries.

We use a comparative case analysis to arrive at three core insights. First, information and communications technology (ICT) has given rise to a type of firm where both the offering and the

[1] Accessed June 6 2011, http://en.wikipedia.org/wiki/Chesscube
[2] Accessed June 14 2011, http://www.clickatell.com/about_us.php
[3] Both ChessCube and Clickatell were founded in South Africa and retain a significant presence there, but neither emphasise their South African origins.
[4] On June 6, 2011: http://en.wikipedia.org/wiki/Skype and http://en.wikipedia.org/wiki/MXit

market can operate purely on-line. This type of firm therefore has a different relationship with its location than the traditional MNC, and targets global markets from the outset. The second insight relates how these firms connect to the rest of the world from their somewhat underdeveloped context: Provided the firm has adequate technological and managerial capabilities – even when their home location and domestic institutions are underdeveloped – they can become lead firms in global innovation networks. Finally, we note the role of contractual agreements and alliances as mechanisms to obtain the capabilities and services the firm needs. In other words, firms create relatively loose networks rather than operate through tightly integrated subsidiaries.

7.2 Literature review

Digital service firms in developing countries, where the technological infrastructure and other capabilities are often underdeveloped, tend to form part of highly global innovation networks. We argue that their underdeveloped home context acts as a trigger for their participation in global innovation networks, firstly because the ICT paradigm allows digital service firms to mitigate many of the constraints of a given physical location, and secondly because those firms are skilled at overcoming what can be termed "institutional voids". We therefore consider first how the emergence of ICT has affected the role of location, and secondly the literature on institutional voids.

It has long been established that although ICT enables a greater dispersion of activities than before, the dispersion strengthens existing locational patterns: Low value-added activities are more dispersed than before, but high value-added activities are increasingly concentrated (Gorman, 2002; Nachum, 2000; Zaheer & Manrakan, 2001). Moreover, high-value added activities are generally located in existing highly developed business centres. Some technical explanations (e.g. that bandwidth matters) have been offered for why ICT has thus far not significantly challenged locational hierarchies, but the key explanation for the persistence of existing locational patterns is that social depth is not the same as spatial reach (Morgan, 2004). Although useful information can be exchanged through the web, advances in ICT still do not enable the type of context-specific complex communications that facilitate trust formation (Leamer and Storper, 2001). The evidence therefore suggests that the emergence of ICT is unlikely to fundamentally challenge the prevailing concentration of economic activity.

A partial exception is the work on how ICT firms use relational networks to respond to the possibilities and constraints of physical distance. In their update of their well-known model of incremental internationalisation, Johansson and Vahlne (1977; 2009) state that firms operate in networks, and that physical distance matters less than trust and commitment. It is well known that physical proximity facilitates interpersonal aspects like trust formation, but the concepts are distinct. Indeed, in their test of the original Johansson and Vahlne model Moen, Gavlen & Endresen (2004) demonstrate that networks, both industrial and personal, play a key role in determining where software firms will locate when they internationalise. Trust is unlikely to be spawned by purely Internet-based relationships, but once trusting relationships exist, the Internet can help relationships function over a geographically much larger space. Thus Cole (2008) finds that the geographically quite distributed animated film producers in Europe rely on events like the annual "Cartoon Forum" to meet like-minded people and identify future opportunities, while ICT technologies allow people from different locations to subsequently work together.

Moriset (2003) argues that two types of ICT firms are emerging. Firms like web agencies and Internet service outsourcers are linked to their clients and broadband networks, and not only remain tied to a specific location, but are also disadvantaged by a peripheral position. At the same time, what Moriset terms a "creative district" is emerging. These are niche providers of services like programming, Web design and graphics – whom Moriset (2003:2183) refers to as "the end of the business intelligence supply chain"– where people can be located away from the centre, even in rural areas, and use connectivity to deliver their services.

The scholars arguing that ICT has a (somewhat) disruptive effect on current patterns of economic activity and location do research on industries that are geographically away from the locations where most economic activity takes place: Moriset (2003) researches ICT firms from Lyon, Cole (2008) the European film animation industry and Moen, Gavlen and Endresen (2004) focus on small Norwegian software firms. All of these firms are trying to find a niche in an institutionally already well-developed context. ICT firms from developing countries face perhaps even greater disadvantages than those firms, but there may also be advantages to their position in institutionally underdeveloped contexts.

The notion of paradigms is useful. It is well-documented that firms, technology and industries co-evolve (Murmann, 2003) and that established economic institutions in countries struggle, because of path dependency, to adapt to new industrial and technological paradigms once they have developed strengths in an existing technology (Cantwell, 1991; 1992). A basic feature of the current ICT paradigm is the trend towards not only globalisation, but also heterogeneity, diversity, and adaptability. This in turn leads to market segmentation and niche proliferation as well as to production disaggregation and segment relocation (Perez, 2002; Perez, 2006: 41-46). In principle, therefore, the ICT paradigm could well hold opportunities for developing countries.

However, in order to realise the opportunities of a new paradigm, new industries need to bring together the "factors of production" needed for success (Storper & Walker, 1989).Although they are not constrained by the existing structure of institutions and competencies, developing countries are at the same time disadvantaged because institutions in those countries are generally underdeveloped and unresponsive (Chaminade & Vang, 2008). The notion of "institutional voids" is receiving increasing theoretical attention in understanding the nature of economic activity in developing countries.

Institutional voids refer to the many inadequacies suffered by developing countries. They include the absence of elements such as well-developed and well-regulated customer and financial markets, a logistics and distribution infrastructure, and an enabling regulatory context where aspects like intellectual property rights are acknowledged and enforced (Khanna & Palepu, 2010). Institutional voids can also relate to deficiencies in educational institutions that are especially crucial for the knowledge-intensive and R&D activities that characterise the ICT sector.

Increasingly, there is a sense that institutional voids – or more accurately, the need to somehow overcome or mitigate them – can present firms from developing countries with entrepreneurial opportunities (Khanna & Palepu, 2010; Tracey & Philips, 2011). In the process of pursuing those opportunities, firms develop capabilities that can be of wider use. Thus Cuervo-Cazurra and Genc (2008) document how MNCs from developing countries, used to operating in an institutionally underdeveloped context, perform relatively well in the least developed countries.

The literature on institutional voids sees the domestic arena largely as the centre for learning and opportunities. For example, one of the commonly documented ways in which business in

developing countries responds to institutional voids is to organise as business groups (Chang & Hong, 2002; Khanna & Yafeh, 2007). Business groups are argued to be beneficial because they internalise numerous functions that are not performed by markets, and thus compensate for underdeveloped institutions. Business groups have a strong domestic focus: Bhaumik, Driffield and Pal (2010) find that concentrated domestic ownership reduces the likelihood of a business group investing abroad. Meyer and Tan (2010) find that business groups can use external connections to become more international, but their focus remains inside a given country.

Moreover, business groups do not always provide developing country firms with adequate capabilities to operate in a given industry – there may simply not be enough skilled people in that industry in a country. This is especially seen in small states, but can also be true of slightly larger but still underdeveloped countries, especially if one uses a relational understanding of small states:

> … being a small state is tied to a specific spatio-temporal context and that this context, rather than general characteristics of the state, defined by indicators such as its absolute population size or size of GDP relative to other states, is decisive…
>
> (Steinmetz and Wivel, 2010: 7).

In other words, size is defined by being the weak partner in an asymmetric relationship and it is a dynamic characteristic of a country, and its impact changes over time. Currently, evidence suggests that smallness is a source of multiple constraints on innovation and economic development in general (e.g. Armstrong & Reid 2003; contrast with Easterly & Kraay 2000). These constraints can be summarized as follows: First, small states do not have the financial capabilities or human resources to invest much into cutting-edge science, research, and development. Second, almost by definition, small states (and more so the less developed they are) have small home markets that limit the possibilities for economies of scale and geographical agglomerations. Finally, their small home markets and the subsequent dependence on exports threaten them with over-specialization, lock-in, and low diversification of the economic structure (Kattel et al., 2010).

However, research on "born globals" provide evidence that firms can respond to small home markets by considering global markets from the outset (Fan & Phan, 2007; Vissak, 2007). Young internationalising firms need an adaptive capacity to the needs of foreign markets (Lu, Zhou, Bruton & Li, 2010), which presents a challenge if firms offer highly localised services. However, some digital service offerings (e.g. many "software-as-a-service" offerings) require only limited localisation and are therefore largely exempted from that requirement. Digital service firms also do not require a physical distribution infrastructure for delivery of the service, further limiting the need for customisation. We argue that the combined small domestic market and the relative ease of accessing global markets create a global orientation among firms from the outset, leading us to our first proposition:

Proposition 1: In less developed countries, the lower level of local purchasing power and limited need for customisation lead digital service firms to consider global markets from the outset.

However, firms are unlikely to succeed in global markets without the capability base to support their internationalisation. The emergence of global networks offers small states and developing countries an additional way to access resources that they do not have at home and to the extent that developing countries can forge linkages in global networks, the potential for "reverse knowledge outsourcing" (Ernst, 2002) exists. Participation in global networks can facilitate not only knowledge diffusion, but also knowledge creation and capability development in developing countries. Rather than develop a domestic response (e.g. by forming a business group) to the problem of

underdevelopment, firms can "supplement" their capabilities through a range of partners from across the world.

Hierarchies in global networks still exist; networks typically consist of a "flagship" firm and the other network partners (Ernst, 2002). Generally, firms from less developed country tend to be contractual partners rather than the lead firm as they do not possess the needed core technologies. Although it is rare for firms from developing countries to have both the technological leadership and the managerial expertise to occupy the leading role in a global network, it is in principle possible. Because of the power of path dependency, we argue that developing country firms are more likely to occupy lead roles in global networks in new and somewhat turbulent industries, where leadership positions have not yet been cemented. The rise of ICT and digital service firms creates such an opportunity, especially if a developing country firm can create a substantial innovation, and follow it up with a strong vision and management. This leads us to our second proposition:

Proposition 2: In less developed countries, digital service firms succeed in establishing global innovation networks to the extent that they have extensive capabilities both in terms of technology and management skills.

However, it is likely that digital service firms from developing country firms will struggle to find the needed capabilities domestically to support ongoing global growth. Developing countries are characterised by underdeveloped educational institutions, and especially because institutions in developing countries are generally slow to respond to changing needs of industry (Chaminade & Vang, 2008), emerging industries may not be able to source the needed skills from their home context. There is a growing literature documenting how developing country multinationals ("emerging multinationals") access resources through their presence in the more developed world (Borini, Fleury & Fleury, 2009; Gubbi et al., 2009), and digital service firms are likely to also look abroad for needed competencies.

However, ICT firms are less likely to organise in the same way as most MNCs. Ernst has pointed out that the use of externalised resources is a worldwide trend in ICT:

> No firm, not even a global market leader like Intel, can mobilize internally all the diverse resources, capabilities and bodies of knowledge that are necessary to fulfil this task [i.e. achieve an ROI acceptable to investors]. As a consequence, global firms increasingly 'externalize' both the sources of knowledge and its use.
>
> (Ernst, 2010:313)

This trend is of particular benefit for firms from less developed countries, because for them, externalised sources of capabilities (i.e. those that can be procured through the market) are more accessible than internalised sources (Barnard, 2010). To the extent that firms are still "outsiders" in the global economy, they may struggle to establish close ties with quality partners in the developed world. Relatively loose, contractual relationships are a more likely avenue for accessing competencies from leading firms. In time, driven by mutual recognition of the worth of the relationship and the need to have more direct control over the actions of partners, relationships may become hierarchical, but hierarchical governance is likely to be rare. This leads us to our third proposition:

Proposition 3: The sourcing of capabilities for virtual services firms is less often done through subsidiaries, and more commonly through contractual relationships or partnerships.

All three our propositions suggest that the most competent digital service firms from less developed countries are likely to create and operate through global innovation networks, and that those networks evolve not in spite of, but because of the institutional voids that these firms need to contend with.

7.3 Methodology

This study relies on a comparative case analysis. We specifically focus on the relationships that firms with less technologically advanced home countries have with their home country and with the rest of the world. Our two exemplar firms, Skype and MXIT, are similar across numerous dimensions (see Table 1), notably the nature of their offering and their origins in countries with an underdeveloped technological infrastructure, and differ primarily in terms of size[5]. Skype has about 20 times the user base of MXIT, making it possible to establish whether or not internationalisation at some point – albeit only once a much larger customer base has been developed – starts to follow a more traditional pattern, including that of traditional MNCs.

Table 1: Details of Skype and MXIT

	Skype	**MXIT**
Country of founding	Estonia	South Africa
Year of launch	2003	2005
Platform	Initially PC-based, increasingly multiple platforms	Mobile-phone based
Main offering	A suite of social networking offerings, including voice call, phone call, video call, instant messaging, desktop sharing and file sharing	A suite of social networking offerings, primarily instant messaging with services like file and photo sharing. Also offers an on line currency for use in their e-commerce site for offerings such as participating in chatrooms or buying music.
MNC ownership	Microsoft (US-based ICT company) 100% share bought in 2011 US$ 8.5 billion In 2005 the US-based ICT consumer-to-consumer company e-Bay had purchased a 100% share in Skype, reduced to 30% in 2009.	NasPers (South Africa-based media company) 30% share bought in 2007 Undisclosed amount
Current user base	About 663 million users	About 27 million users[6]
Targeted user base	Global	Emerging markets, youth

Interviews were conducted during 2010 and 2011 – five interviews at MXIT, and three at Skype. Interviews were conducted with the top management of each company, as well as division heads

[5] At the time of data gathering, Microsoft had not yet acquired Skype. The US-based firm e-Bay had a 30% share in Skype, while MXIT was 30% owned by a South African media MNC, Naspers.

[6] LinkedIn, accessed June 10 2011, reports 34 million users: http://www.linkedin.com/company/mxit-lifestyle

such as Sales and Product Development. The interviews were anchored in specifics, e.g. "explain your relationship with partners" and were conducted in English at MXIT and in Estonian for Skype[7]. Interviews were supplemented with archival data, including press releases, published interviews and online commentary.

The interviews were transcribed, and core themes for each company identified. For example, a number of interviewees at MXIT mentioned perceptions of the wider South African community in response to previous bad press. However, themes were included in the paper not only if they contributed to a more fine-grained understanding of how the firms do business from their relatively underdeveloped local institutional context, but also if themes were addressed by both firms. Because the researchers wanted to have a comparative view, researchers cross-checked with each other to find if themes found in one set of interviews were found in the other. It is however important to note that what was looked for was similar themes (e.g. Skype did not seem concerned about local perceptions, so that theme was dropped) rather than a similar content of responses (e.g. Skype and MXIT both discuss their market orientation, so that theme was included, even though their approaches are quite different.)

Using this approach, it became clear that ICT has given rise to digital service firms that are highly globalised, but operate quite differently from the traditional MNC in terms of global location. Three core themes emerged. First, in terms of markets, digital service firms from developing countries internationalise from the outset, but small "listening posts" rather than the much larger traditional sales office is needed for even their most important markets. Second, these firms can become lead firms in global innovation networks if they have substantial technological innovation and managerial resources. Finally, digital service firms from developing countries use the relative ease of global procurement to access capabilities and suppliers from across the world, rather than try and upgrade underdeveloped capacity in their home country. In other words, provided that the firm has a strong enough initial capability base, its underdeveloped institutional context acts as a trigger for the emergence of a global innovation network.

7.4 Results

Proposition 1 states that in less developed countries, the lower level of local purchasing power and limited need for customisation lead digital service firms to consider global markets from the outset. The tremendous scope of Skype's reach at this point is clear evidence of its global dispersion, but even the much smaller MXIT has a global orientation and MXIT states its Facebook page[8] that the firm aims to "secure two percent of the world GSM phone population within the next 3 years as clients".

Although Estonia is generally considered a successful transition economy, it has a population of only 1.4 million and therefore a small market. South Africa has a much larger population (about 50 million), but the cost of its telecommunications is extremely high. MXIT started when the founder tried to develop a mobile game and realised that the prohibitive cost of telecommunications would dramatically limit the population that could participate in an interactive game[9]. Instead, MXIT

[7] Skype interviews were translated for use in the study.
[8] http://www.facebook.com/#!/pages/MXit/6544563914?sk=info, accessed June 10 2011.
[9] Data cost about R 50 a megabyte, a cost that has since come down to below R 2.

focused on ways to circumvent high telecommunications costs, and developed a mobile instant messenger, targeting a younger market with a dramatically cheaper alternative to SMSs.

Skype similarly evolved differently than its inventors had originally anticipated. Skype's founding entrepreneurs Zennström and Friis[10]developed and launched peer-to-peer file sharing software named "Kazaa" in 2000:

> We uploaded the programs to a web server and entered links on http://download.com and other shareware sites. Then we just sat down and waited for something to happen.
>
> (Friis, quoted in Goodstein, 2002)

It rapidly became hugely popular: Without any marketing spend, a new user was registered every second in the summer of 2001. However, Kazaa, like Napster and similar file exchange services were starting to experience legal challenges from major record companies which found the Internet-based free file exchange a major threat to their established business models. Initially, Zennström and Friis fought back, but sold Kazaa in January 2002 to Australia-based Sharman Networks to distance themselves from further legal disputes.

However, they retained control over their peer-to-peer networking technology and were looking for new applications for it. Zennström and Friis had understood the disruptive power of their peer-to-peer technology and wanted to launch another major Kazaa-like project. They were discussing possible new application areas for their technology when the idea of peer-to-peer telephony software emerged in summer of 2002:

> Now we are working on a project named Skyper. We believe it has the potential to become as huge as Kazaa.
>
> (Friis quoted in Goodstein, 2002)

Skype's global focus was facilitated by disruptions in telecommunications technology. The rapid spread of the Internet made VoIP technology increasingly feasible: Telephone calls could be routed over the Internet, where international communications are virtually free of charge and traditional billing per minute of use does not apply. However, take-up of such VoIP systems was slow, as standard VoIP systems are tricky for an average end-user to set up. The competing VoIP service providers modelled their technological infrastructures and business models on the traditional public telecommunications operators that relied on (costly) central exchange(s). Because traditional VoIP networks are subject to a myriad of different telecommunications regulations that vary across countries, the market was defined nationally rather than globally.

Contrary to its competitors, Skype developed a proprietary version of a system that is user-friendly, highly scalable and allows the rapid build-up of a massive global client base. Although the founders of Skype were originally not interested in the market for international voice calls[11], the development of a global VoIP offering allowed Skype to consolidate the fragmented global market and in a few years develop a substantial user base.

[10] Zennström and Friis are Swedish and Danish respectively, but worked with four Estonian engineers in developing Kazaa and later Skype.

[11] It is perhaps worth mentioning that Zennström's and Friis had earlier knowledge of the telecommunications industry, obtained when working in the Scandinavian telecom company Tele2.

Building up a large client base is important. In a context without substantial local connectedness and where network effects easily crowd out competitors, digital service firms easily find themselves in "winner-take-all" markets (Lee, Lee & Lee, 2006) – think of Google and Facebook. At the same time, the marginal cost of delivering the service to another user is close to zero. Skype ensured large user numbers across the globe with its business model, the so-called "freemium" model. This model, used by a number of Internet content providers, involves providing the basic service for free, while some users pay for extra services.

> It's the same thing with Skype. Some users are paying for services, but not everyone
>
> (Zennström, quoted in BBC, 2005)

MXIT operates with a narrower focus on emerging markets, and within emerging markets, the (substantial) youth market. However, its outlook is still fundamentally global, and as we hold in Proposition 1, driven both by limitations in the local market, and by the relative ease of adapting the offering elsewhere. This global focus is translated firstly into the way the software was developed for an underdeveloped context:

> We developed the software to be extremely lenient on bandwidth, and efficient. And then we spent a long time to make sure that everything doesn't break when the network disappears or the signal disappears, so it keeps on. The user still thinks the link is there but it is not and in the meantime in the background, we try like hell to re-establish the link because the GPRS just disappeared.
>
> (Heunis, 2010)

Secondly, MXIT has oriented itself to emerging markets and is involved in South-East Asia (especially Indonesia), a number of African countries, and currently Mexico City. The head of Sales points out that part of the strategy is to compete in "non-English" markets, with the argument that competitive pressures there are less severe, because other Instant Messaging services and other brands find it harder to operate in those markets. However, language may not be such a barrier, as is perhaps best seen from the CEO's surprising explanation for MXIT's growth in its second-largest market, Indonesia.

> In Indonesia we didn't decide; it just happened. We have a guy that worked in Jacarta who is slightly versed in the language you speak in Indonesia, a little bit, about 500 words. And someone posted a posting on our forum where we do technical support, and he answered the thing in Bahasa, but as 'MXIT team'. That was the sum total of what we have done.
>
> And then we started growing at ten a day, fifty a day, one hundred, two hundred a day, five hundred a day, thousand, two thousand, three thousand, four thousand, five, six, seven, eight thousand a day, and then the operator network collapsed. And then it went down to one thousand a day, because we flooded their networks and they didn't have enough space on their networks. So it is only now starting to pick up again, and that is about eighteen months ago.
>
> (Heunis, 2010)

In the course of that growth process, MXIT conducted focus groups to better understand the Indonesian market. Commissioned research also provided useful information, e.g. that a single user in Indonesia would often own two handsets, used for different purposes, whereas in South Africa it is more common to have users share a single handset. In addition to estimating the size of the market, MXIT must understand cultural and communication practices in a potential market: In

Kenya the 'Dating Game' had to be renamed 'Rendezvous' because overt dating was societally less acceptable. Also, many possible target markets (including Indonesia) are Muslim, requiring care in terms of what is put on the MXIT platform.

As for the technical requirements needed to address the needs of a given international market, the two main elements are translation and modularisation, as explained by the Executive Product Manager.

> With Indonesia where we have had to translate it, it has created an enormous amount of work for us. Instead of just extracting copy to be translated, you need to look at it and say 'okay, well, hang on a minute, if this happens for another two or three countries… Let's rather change how some of the foundation works so that we can change it quicker in future'.
>
> (Geldenhuys, 2010)

One example is the MXIT currency. It used to be integrated into numerous MXIT services, but operated differently in different countries. To reduce the need for rework, the currency service was taken out and developed as a separate MXIT service. As onerous as the task may be, it is relatively little work for dramatically expanding the scope of their operations.

Proposition 2 holds that in less developed countries, digital service firms succeed in establishing global innovation networks to the extent that they have extensive capabilities both in terms of technology and management skills.Although both Skype and MXIT introduced innovations that were world-firsts, they have struggled to find the needed capabilities domestically to support on-going global growth. The majority of engineering activities still take place in home countries where these activities were historically rooted, but building tailored business models and developing technological excellence to overcome institutional voids have been key to their success.

The extent to which Skype innovates through a global network is evident from its patenting. Most of Skype's patents are assigned to its Irish office (Tiits and Kalvet, 2010: 38), although most of the R&D and engineering is carried out in Estonia – with, however, deeply cross-national teams.

> We expect our new employees to work with interdisciplinary teams in sixteen time zones and of dozens of nationalities, but Estonian education establishments do not prepare such people. This applies also to some specific fields crucial to our technology development.
>
> (Tamkivi, 2010)

Because of an institutional void in terms of a quantitative and qualitative lack of engineering talent in Estonia, Skype has been explicitly attracting the required talent from elsewhere, e.g. from Stockholm (Sweden) and Prague (Czech Republic),

> Nowadays, in this Skype Stockholm office, some of the most advanced audio-video R&D in Europe takes place. Given the deep specialisation and the knowledge pool that is available in this Skype unit, a close exchange of information also takes place there with different research institutes and universities across the globe.
>
> (Kütt, 2010)
>
> We have successfully implemented a management model where the various multidisciplinary teams operate indeed in most cases within Skype, but on a trans-country basis. For example, the Prague engineering centre operates today largely as a satellite of the primary engineering centre in Tallinn. The Prague-based developers report to the team leaders who typically are located in Estonia. It is also quite common for the product managers and other mid-level

> managers who are in charge of development to be located part- or even full-time outside Estonia, for example in London or elsewhere.
>
> (Lind, 2011)

In contrast to this cross-national cooperation and coordination, Skype's cooperation with the educational system in Estonia has so far remained fairly limited, since the public education system is slow to respond to changing needs (Kattel and Kalvet 2006). Skype's participation in the Software Technologies and Applications Competence Centre, established in 2009, is described as:

> Our next attempt to build stronger cooperation linkages with the local R&D system so that benefits would appear in the long run for both sides.
>
> (Kütt, 2010)

Skype had to find resources abroad in its early expansion phase, as it could not afford to wait for actual results. A concern about the education system in South Africa is also expressed by MXIT:

> There are some initiatives in Cape Town, they have tried to start a few times, but this is always very lacklustre, where we try to find laaities [colloquial for youngsters] and if they engage a little bit more on actually formalizing that kind of training a bit more. […] But in the end if government only has to build…Ag, I have seen so many incubators and so many ideas and it is good ideas but there is no follow-through.
>
> (Stemmet, 2010)

Financing is another dimension where the local (for Skype, European) institutions were not supportive enough. The founders of Skype approached about ten different venture capital firms from 2001 to 2002 (Zennström in Vilpponen, 2010), and finally acquired seed financing from Silicon Valley-based Draper Fisher Investments. The international venture capital funding clearly added to the global dimension of the Skype's operations, as they were to cross continents from the outset.

Although MXIT secured funding from a South African multinational, the founder of MXIT explains that he had spoken not only to Rudolph Botha, a South African at Sequoia, a Silicon Valley venture capital firm, but to a number of other venture capitalists there, and that they were all well aware of MXIT. Like for Skype, it is important for MXIT to ensure visibility in the wider economic community.

For Skype, another void – a credibility void – was addressed by the establishment of corporate headquarters in Luxembourg and an office in London. Skype's presence in these economic centres also helps advance relations with international venture capital and marketing. Because MXIT targets emerging markets, its credibility in more developed markets is less critical. However, it is constantly positioning itself relative to the wider world:

> The mobile technology in Africa and our mindset of mobile technology is so much more advanced than any that we have seen internationally. Because we've had to be: We're way ahead of the pack in mobile technology, because they've always looked at digital and online technology.
>
> (Hallam, 2010)

> We read a lot. We are aware of everything that is happening in the world, and everyone in the company – we are inquisitive beings. Well, the tech South Africans, we are well aware of what everyone is doing in the world.
>
> (Heunis, 2010)

In sum, Skype has successfully managed, over various phases of explosive growth, to build up a complex corporate management system. Skype's very rapid globalisation experience has been, for the most part, about securing access to talents, marketing channels, strategic partners and venture capital that have collectively allowed this firm to become such a success. Skype became a success story thanks to its international management and start-up financing, which all came together at the right time, namely the disruption VoIP technologies brought to the telecommunications industry. World-class management and strong venture capital backing also allowed Skype to select the right global spots for its different activities, overcoming in this way the institutional voids in its initial locations in Estonia and Sweden.

The MXIT story is more modest. It has a much smaller user base, a smaller R&D operation – six full-time employees – and is focused on a niche market: Mobile applications for youth in emerging markets. However, it also relies on visionary leadership and innovation, both technological and in business models, in order to overcome the disadvantages of its home location. In contrast to Skype, it has no fully-fledged subsidiaries in the rest of the world, although it does have some "listening posts" abroad. But MXIT, perhaps even more than Skype, provides evidence of Proposition 3: That digital service firms from less developed countries will source capabilities more commonly through contractual relationships or partnerships than through subsidiaries.

We argue that for developing country digital service firms, core functions will remain internalised, but firms are likely to define their core activities quite narrowly. In terms of partners, we distinguish between independent strategic partners and "multipliers". Independent strategic partners such as major web portals or payment partners have their own client base, but play an important role to increase the reach of the firm. In contrast, "multipliers" are the many, smaller independent firms that build various value-added services on each firm's platform. There are typically no major knowledge assets involved, and firms are controlled indirectly through the control of the core technology platform.

MXIT seems keenly aware of the need to firstly focus on its core technology, but also ensure that it manages its external partnerships:

> Really, it is not our business to develop games. Yes, we would like to do it, but it is not our core business; our core business is to have a messaging system and social network and to build all the hooks and the billing engines and the transaction engines and that sort of stuff, but create an environment for external parties to still make a decent living.
>
> (Heunis, 2010)

The founder pointed out that MXIT's main source of revenue is advertising, with content sales as a secondary source of revenue. He speaks of numerous "commercial agreements" with such companies – the Head of Sales claimed that there are more than five or six hundred advertisers. Although these are arm's length agreements, MXIT is very involved in each relationship:

> We guaranteed Nike that X number of users would see their advertisement, and there are not many people who would do that for you. So it wasn't just Nike coming to us with a campaign. […] And because of this, we are now positioned to roll out more campaigns for them in Brazil

> for the next Soccer World Cup. We at MXIT attach to brands for advertising in other markets where we are not so big. So we use their advertising clout to grow our brand. Because they just spend ten times more than we would ever spend on marketing.
>
> (Stemmet, 2010)

The rationale for the very close interaction can be seen from his last sentence: MXIT's well-established business partners allow the firm to magnify its reach. The person driving Social Business and Education also relies heavily on partners, most of whom are not South African:

> The partners I have I am quite proud of; they are quite high level – Nokia Finland, Shuttleworth Foundation[12], BBC. Be Smart is a partner in the UK and they recruit a lot of the donors and funders and civil society internationally. And then the UN agencies, UNDP, Unicef NY, Washington and South Africa. What my next stage now is with the UN agencies.
>
> (Hallam, 2010)

All these partners have a distinct identity and strategic imperative, and they work with MXIT to the extent that collaboration is mutually beneficial.

Skype has also a long history of marketing cooperation with the major web portals, such as TOM-Skype in China or PCHOME-Skype in Taiwan, whereby specific co-branded software has been developed so that Skype could extend its own user base. Recently, Skype has also started to leverage the Facebook client base by building a fully functional Facebook client (including Facebook chat) into Skype. Similar cooperation pattern has been also visible in the mobile instant messaging sphere, where Skype allowed prominent multi-platform service providers such as Fring or Nimbuzz to offer access into Skype communications network. Recently, Skype has cut back on such cooperation – probably suggesting that it no longer needs the validation of partners.

Both groups also have another group of less visible partners, "magnifiers". These partners do not contribute to either firm's visibility or credibility, but they do increase capacity. ICT firms can access work remotely relatively easily, and in a less developed context, remote sourcing is a solution for firms struggling to source capabilities locally. Given MXIT's much smaller size compared to Skype, it is perhaps not surprising that MXIT relies more heavily on such "magnifying" partners, but both firms provide evidence of this type of partnership.

In August 2007, to a significant extent driven by cost considerations, MXIT commissioned a European Data Centre in Frankfurt, Germany to take over most of the international traffic from South African servers. The head of Sales explains:

> And our interconnection in South Africa, because of Telkom [the state telecommunications near-monopoly], it is really expensive. […explaining that about 10.5 terrabytes of data must be moved monthly] So it is quite a bit of data, and you are looking at over one million Rand[13] for that, to move about a kilometer. And it is just because of the rules, it is starting to change now but you need good infrastructure and good laws.
>
> (Stemmet, 2010)

[12] http://www.shuttleworthfoundation.org/about-us/, accessed June 12 2011, is founded by Mark Shuttleworth, a South African who developed Thawte and sold it at a substantial profit to VeriSign, and who subsequently developed Ubuntu, an open-source operating system.

[13] The Rand/dollar exchange rate is variable, but R 1 000 000 would be more than US$ 140 000.

One of the main mechanisms used by digital service firms to enable collaboration is "APIs", application programming interfaces, which are rules and specifications that software programs can follow to communicate with each other.

> Generally companies like Twitter and Facebook make external APIs available. So our technical people can simply go and see what the external API allows us to do and integrate with it. There are no requirements.[*So you have no contact with the actual companies?*] No. I mean with Twitter we had… I am trying to remember, oh, it was fairly technical but I think their API allowed us to access via PC but not mobile. So then we just emailed their development team and said this is what we do, we would like to request permission for this, and there was a different API as well that we would like to request permission to use, and they granted it and we went ahead. So there is no huge relationship-building.
>
> (Geldenhuys, 2010)

The benefits of having integrated software vary. It is clearly beneficial for firms like Skype or MXIT to link to a prominent firm like Facebook, but MXIT also uses APIs to encourage external parties to develop content for them. For MXIT, these external parties contribute to enriching the content that they can offer to their users, and represent an important alternative source of capabilities:

> We will launch an API for external developers to develop software on MXIT and we have one already, it is a small company in Cape Town, Blue Leaf I think. They launched a game called Moonbase, very rudimentary, but it is so addictive even I play! We are not paying them, but we share revenue with them, and we share I think quite fairly. We give them 70% of the revenue, and we take 30%. […] That is a very important part of our future, to make sure that we create a system that is beneficial to these sort of people, because face it, there are far more creative people out there than us.
>
> (Heunis, 2010)

In planning for the future, the CEO does not rely on systematic improvements to a flawed institutional infrastructure. Instead, he plans to structure his company so that it functions as a system that will attract entrepreneurs from a variety of contexts. The strong emphasis that MXIT places on managing contractual relationships suggests that the firm sees these relationships as a viable alternative – or at least complement – to internalised capabilities.

For Skype, similar collaboration schemes extend from basic engineering activities to include various approaches to build up integrated innovation networks. At the basic level, Skype has been using various sub-contractors in software development, where the in-house capacity has not been sufficient for carrying through certain development tasks. While doing so, the development of the Skype's core libraries and systems has been kept internal and carefully protected. As the number of different software and hardware platforms that Skype seeks to support continues to increase, Skype has also started to open up its platform for selected third-party developers, e.g., flat screen TV or car manufacturers.

Skype has thus also become a central coordinating node of an even broader network of software developers and hardware manufacturers who are developing the Skype client software or the various devices that support the Skype communications platform. The recent Skype-enabled TVs from Samsung and Panasonic are perhaps the most prominent examples of such partnerships.

But although sourcing capabilities contractual relationships or partnerships is important, subsidiaries are more important for Skype compared to MXIT.

> Skype currently employs 850 staff, with most of its engineers in Estonia, though its disparate operations include a Luxembourg headquarters, marketing operations in London and audio-visual engineering in Stockholm.
>
> (Bates, quoted in Water, 2011)

Subsidiaries in Singapore and Hong Kong handle the marketing, sales and support in Asia. Their perhaps even more important function is to maintain close contact with the manufacturers of the increasing variety of Skype-enabled devices, including flat screen TVs in Asia. Given its relationship with eBay, a Skype office was also set up in the United States close to eBay's headquarters. The Skype office in the United States continues to operate as marketing, sales and support office servicing the Americas. Even before the Microsoft acquisition, general management of the Skype4Business business line was moved to the U.S., as the Americas are globally the largest market for enterprise communications, and some of Skype's strategic partners for this business line, e.g. Avaya, are located there.

Skype has also been engaging in acquisitions in search of top talent. The purchase of the Norwegian start-up Sonorit, a provider of voice technology for the Internet, in April 2006 is an example of the flexibility companies like Skype exhibit in attracting top talent. Early 2011, Skype acquired another well-known Internet video communications firm Qik, in order to further reinforce Skype's video functionality.

7.5 Discussion

The evidence from this paper suggests that digital service firms from developing countries develop increasingly global and diverse innovation networks because they come from a context where many competencies are not readily available. Connections to the institutionally underdeveloped home country of both firms are largely incidental and the location seems to reflect the founders' preference at the time of founding. Although there are substantial voids in their home context, firms invest little in improving their home context. Instead, there is from the outset a commitment to source markets and technology wherever on the globe they are best found.

The firms studied in this paper are unusual: They belong to a small minority of firms that provide a purely digital offering for a market potentially spanning the entire globe. Most firms still have tangible deliverables, many service firms still require face-to-face contact, and even digital service firms often provide a location-specific offering (e.g. e-government services). But evidence suggests that information technology is increasingly reducing MNCs' propensity to internalise across national borders (Rangan & Sengul, 2009). Precisely because they operate entirely digitally, firms like Skype, Google and Facebook in principle do not need extensive engagement with any given country in order to succeed. Their "digitalness" raises questions about the role of location in an increasingly digital world; questions that are brought in even starker relief in when those firms originate from an underdeveloped location.

The bulk of prior evidence suggests that digitisation will not dramatically change existing locational patterns (Gorman, 2002; Morgan, 2004). Our evidence suggests the same: Although they retain a (sometimes quite substantial) proportion of their activities in their home country, the firms in our

study are not investing in the upgrading of their home context, and instead connect to leading locations through the use of global innovation networks.

Research on developing countries has long documented the importance of business groups (Chang & Hong, 2000; 2002; Khanna & Yafeh, 2007). Business groups are relatively loose groupings of companies that help firms to overcome the constraints of their domestic environment. In many ways, the global innovation networks of Skype and MXIT perform a similar role to the business groups typical of developing countries. Many partner firms have their own client base, and the digital service firms use partnerships with those firms to magnify their own reach. To the extent that those partnerships help digital service firms from developing countries overcome the limitations of their home country, their global innovation networks can be seen as the global equivalent of business groups.

Indeed, firms from developing countries may have an unusual advantage over firms from more developed countries, where the resources to internalise activities are more accessible. Although digital service firms from developing countries must overcome many locational limitations, managers in those countries generally have more experience coordinating activities through loose networks. In many industries, that capability is of little use[14], but in the ICT industry it may provide some competitive advantage.

Our evidence suggests that firms must have an initial level of technological and managerial expertise to take up the lead position in a network, but that they can access additional resources from across the globe from that position. Because "externalisation" through various forms of contractual relationships is so prevalent in the ICT industry, partners can cooperate with a range of firms. This means that a potential partner need not be concerned about being locked into a relationship with a firm that proves to be marginal. For digital service firms from developing countries, the looseness of the relationship increases the likelihood that they can access quality partners. The evidence therefore suggests that digital service firms can become world leading firms to the extent that they are able to initiate and manage a global innovation network, even if their home country is less developed. International networking (activities to acquire and maintain connections with external sources of social capital, including individuals and organisations) and international collaboration (cooperative efforts between firms and other innovation actors to explore or exploit technologies or business opportunities) are therefore crucial. Both activities allow enterprises to rapidly fill in specific knowledge needs and commercialise new services.

Skype and MXIT have been very successful in spite of the lack of active local public policies supporting them. But could more supportive policies have helped them achieve even more – in the past and in future? In the context of emerging global innovation networks, policymakers face a considerable challenge in modifying the institutional context. Numerous and often unconnected public policies towards science, technology, intellectual property, competition, entrepreneurship and education can help for successful cases to emerge and develop (De Jong et al., 2010).Our evidence suggests priority policy steps: The supply of high quality ICT specialists (e.g. scientists and engineers) must be prioritised in order to succeed at international ICT R&D. Also, international business and technology management skills must be advanced as they enable better use of strategic R&D and business alliances.

[14] Except when expanding to other underdeveloped countries, as argued by Cuervo-Cazurra and Genc (2008).

However, firms' success may result in only limited spillovers to the home country, and in fact, the possibility of long-run disconnectedness. In the case of highly internationalised innovation networks, gains from technological change and innovation do not seem to travel well within regional or national geographic boundaries. Highly specialized networks operate and source production and knowledge often supra-regionally or even globally. This further entrenches existing spatial divisions, with the risk of enclave economies and de-linking effects. Prior evidence has suggested that foreign direct investment from more developed countries may marginalise less developed countries – Gallagher and Zarsky (2007) illustrate how no backward or horizontal linkages were created in the Mexican ICT industry because foreign firms would import most of their inputs. Our cases differ from their example in two ways: First, in each case, the leading firm in the innovation network is from a developing country, and second, both firms have some integration with local innovation systems. However, more studies are needed on the role of location, e.g. possible long-run disconnectedness, of global innovation networks.

7.6 Conclusion

Firms selling digital services operate in a globally dispersed way and use the world as a reference point when considering both what constitutes a market and its boundaries, and think similarly about the acquisition of capabilities and suppliers. But even though the international orientation of these firms is as high (if not more so) as traditional MNCs, the sourcing of capabilities is often not done through subsidiaries. Instead, contractual relationships and partnerships are more common. Although firms do set up subsidiaries – Skype has quite a few subsidiaries – it seems that more formal structures happen only once firms are much larger. Even firms with a substantial global user base can operate, with partners from across the globe, in geographically dispersed loose networks. MXIT, with its market positioning as a social network service for developing countries, is more engaged with local issues, but with the much larger Skype, there is very little local engagement. This is partly because ICT firms can more easily procure and monitor inputs from across different locations, but for firms from technologically less developed countries, this trend has a specific driver. Firms often find it easier to procure inputs globally than to attempt to engage with their often underdeveloped and inadequate home country institutions.

In other words, the local factor conditions that may be seem to potentially limit the formation of global innovation networks are actually triggers for their emergence. Firms need extensive technological and managerial capabilities to take up lead positions in global innovation networks, and the initial technological innovation and the vision of the founders are critical. But because firms rely on the vision of few founders and on a global (rather than local) network, they do not need systemic engagement with the home country.

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