Technology Transfer in the Irish Food Industry: Researcher Perspectives

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Introduction

The public R&D system represents an important part of the framework conditions for carrying out innovation activities and creating commercially applicable knowledge (Drejer and Jørgensen, 2004). It is an important source of information for companies, particularly those that are developing new products (Tijssen, 2004). However, Rubenstein (2003) stated that there has been a perception that public research capacity and results were not being optimally used and thus that potential economic benefits were not entirely realised. It is also suggested that research conducted in the public sector is not efficiently or successfully transferred to industry (Markman *et al*, 1999) and that it is necessary to understand and improve the means of technology transfer for society to reap the benefits of public science (Geuna and Nesta, 2003). Thus, there is a growing interest, and indeed pressure, among policymakers and academics to ensure informed spending of taxpayers' money, that useful and relevant research is conducted that represents good "value for money" and that wealth is generated from publicly-funded research (Carr, 1992; Lyall *et al.*, 2004; Mustar *et al.*, 2006). To achieve this requires, amongst other things, the establishment of scientific and technical human capital which is the sum of researchers' professional network ties and their technical skills and resources (Bozeman and Coreley, 2004). This paper examines the interactions engaged in by researchers from Irish public science providers (public research centres and higher education institutions), with a particular focus on researchers-industry interactions, as well as their skills and resources. To provide context, it firstly briefly outlines the actors involved in conducting publicly funded R&D in Ireland. It then describes the methodology and presents the results of a national survey of publicly funded food researchers focusing on the extent and nature of researcher interactions with other researchers and with industry, the barriers to and motivations for researcher-industry interaction and researcher skills regarding technology transfer. It concludes with a discussion and some policy recommendations.

The public R&D system in Ireland

The science base in food research in Ireland is mostly concentrated in public research institutes (predominantly Teagasc) and the universities and to a certain extent in the institutes of technology, with some basic research undertaken in the private sector (ICSTI, 2002). The level of R&D conducted by the private sector is low with 120 R&D performing companies in 2003, spending approx €29 million (Forfas, 2006). Thus, public research plays an important role in the development of the food industry's knowledge base in Ireland.

Using allocation of the main source of national funding for publicly funded food research, the Food Institutional Research Measure (FIRM), and its predecessor the Non Commissioned Food Research Programme (NCFRP), as an indication of activity, it is clear that the major food technology producers in Ireland are Teagasc, University College Cork and University College Dublin. (See Table 1). These institutions differ somewhat in their focus. Teagasc is specifically charged with supporting the Irish agri-food industry to attain the highest standards of safety, quality and innovation in food products and ingredients. Research is the focus and technology development services and training programmes are seen as associated services. In contrast, the universities have a broader remit with a very strong focus on education. They view the development of high calibre graduates for the food industry as an important part of their contribution to the food sector. This could suggest the motivations and barriers to technology transfer could be different in the different organisations. Differences in motivations between different types of organisations, with implications for technology transfer, have previously been identified in literature (e.g. Joly and Mangematin, 1996; MacBeth, 2002)

Table 1. FIRM Awards 2000 – 2005 and NCFRP Awards 1994 - 1999

Institution	Total Award FIRM €	% of total awarded	Total Award NCFRP €	% of total awarded
Teagasc	22,773,889	38.1	23,112,530	42.7
- Ashtown Food Research Centre	12,437,584	(16.4)	23,112,530	42.7
- Moorepark Food Research Centre	10,336,305	(19.7)		
University College Cork	18,725,707	29.7	17,880,646	33.0
University College Dublin	12,279,538	19.5	8,397,624	15.5
Trinity College Dublin	2,762,896	4.4	1,569,886	2.9
National University of Ireland, Galway	2,200,920	3.5	1,484,931	2.7
University of Limerick	1,581,672	2.5	913,518	1.7
Dublin City University	722,614	1.2	367,431	0.7
Cork Institute of Technology	481,106	0.8	-	-
Dublin Institute of Technology	294,144	0.5	-	-
Public Health South West Area	185,900	0.3	-	-
Waterford Institute of Technology	173,742	0.3	-	-
Limerick Institute of Technology	171,875	0.3	-	-
Central Veterinary Research Laboratory	162,654	0.3	-	-
Food Safety Authority of Ireland	149,368	0.2	-	-
Bord Bia	122,585	0.2	-	-
Athlone Institute of Technology	89,141	0.1	-	-
Institute of Technology, Sligo	65,316	0.1	-	-
Cork County Council	52,500	0.1	-	-
Consumer Liaison Panel	48,671	0.1	-	-
Enterprise Ireland	-	-	448,155	0.8
Total	**63,044,238**	**100**	**€54,174,721**	**100**

Source: Department of Agriculture and Food, 2006 (Geraldine Corcoran)

Table 1 shows that the commitment to publicly funded food research has increased in monetary terms from the NCFRP to the FIRM. In addition, the number of institutions partaking in food research programmes funded under these programmes more than doubled over the period 1994 to 2005. The recent involvement of the Institute of Technology sector as both project co-ordinators and project partners in particular is notable. (In Ireland, the institutes of technology have only relatively recently been enabled by statute to conduct research (Forfás, 2001). Collaboration between appropriate institutions has been encouraged within the FIRM and NCFRP.

Methodology

A list of researchers involved in publicly funded food research was compiled from various databases, attendees at launches of various EU and Irish funding calls, websites of relevant food research institutions, input from key informants and personal knowledge of the authors. This resulted in a database of 324 researchers involved in publicly funded food research in Ireland.

A postal questionnaire was developed following a literature review and exploratory primary research using focus groups and consultation with public researchers and industry personnel. A pilot was conducted with researchers from a public research centre (PRC) and a higher education institute (HEI[1]). Subsequently, the final version of the questionnaire was professionally printed. Topics addressed in the questionnaire included: the nature of researcher-industry interaction; importance and effectiveness of various technology transfer activities; perceived barriers and obstacles to technology transfer; and the role of public research, science providers and public researchers in the innovation system. The questionnaire was sent to all researchers on the database with a pre-paid addressed envelope. A response rate of 46% was achieved following postal and telephone reminders.

Respondent profile

Table 2 shows that most researchers were male, in the 31-40 years category, without previous industry experience. Slightly more respondents were employed in higher education institutes (HEIs, universities and institutes of technology) than public research centres (PRCs).

Table 2. Profile of Respondents

	Category	n	%
Gender	Male	88	60
	Female	56	40
Age group	21-30 years	29	19
	31-40 years	56	38
	41-50 years	35	23
	51-60 + years	29	20
Industry experience	Yes	36	24
	No	111	76
Organisation	PRC	69	46
	HEI	80	54

Respondents were actively engaged in food research (78% of their research time is food relevant) with a focus on applied research (60% of time spent on applied research, 22% of experimental research and 18% on basic research).

1. HEIs include universities and institutes of technology

Results

Extent and purpose of interaction

Technology transfer encompasses a range of activities including co-operative research, access to facilities, contract R&D and commercial services. Researchers were asked to identify if they engaged with a range of partner organisations under each of these headings over the past 3 years. Table 3 shows that Irish public researchers interact with a range of partner organisations, nationally and internationally, for a range of technology transfer activities. Overall the levels of interaction are quite good with at least 20% of researchers engaging with each category for at least one of these defined purposes. Irish HEIs are the most important partner, with food industry suppliers the least important partner

Table 3. Interaction with selected partner organisation by purpose (% yes)

Partner organisation	**Technology transfer**		**Collaborative research**		**Access to facilities**		**Contract R&D**		**Commercial services**		**At least 1 purpose**	
	%	n	%	n	%	n	%	n	%	n	%	n
Irish HEI	11.4	17	64.4	96	16.1	24	12.1	18	6.7	10	74	111
Irish PRC	5.4	8	47.0	70	13.0	20	11.4	17	6.7	10	60	90
International HEI	3.4	5	38.9	58	8.7	13	4	6	3.4	5	42	62
International PRC	6.0	9	22.1	33	7.4	11	4.7	7	5.4	8	32	48
Food company	18.8	28	23.5	35	18.1	27	19.5	29	22.1	33	53	79
Food industry supplier	7.4	11	7.4	11	5.4	8	4.7	7	5.7	5	20	30

Whilst the levels of interactions for at least one purpose is quite good, the levels of interaction within individual categories are surprisingly low with only one category (collaborative research with Irish HEI) scoring above 50%, i.e. in only 1 category did more researchers collaborate with that partner for that purpose than did not. This is surprising as most national and EU research funding programmes strongly encourage collaboration. In addition, current technology policy in Ireland, as in most EU countries, focuses on developing a range of measures to develop collaborative links between industry and academic researchers. However as data were not collected on the breadth of interaction within each category, it is possible that some researchers could have extensive linkages with a large number of organisations within one or more of the pre-defined categories and that this high level of interaction is masked within the available data. Nonetheless the level of collaboration with food companies is encouraging, at approx 20% for each purpose.

In terms of purpose, Table 3 shows that interaction occurs mainly to conduct collaborative research, with access to facilities, technology transfer, contract R&D and commercial services of lesser importance.

Collaborations are more likely with Irish partners than with international partners. For example with regards to collaborative research, 64% collaborated with Irish HEIs whilst only 39% collaborated with international HEIs. This reflects a dominance of national funding over EU funding for public food research in Ireland despite significant success in obtaining funded though EU programmes. Analysis of interaction with partner organisations by type of research however found that of those who conduct basic research, significantly more people interact with international PRCs than those that do not (see Table 4). Buckley *et al* (2006) cite the benefits for successful participants in EU framework programmes as including access to funds and resources, the sharing of risks and costs, access to project findings and working with leading researchers, thereby gaining new scientific knowledge and research skills. It may be that the latter is seen as particularly important for researchers involved in basic research.

Table 4. Relationship between interaaction partner and type of research undertaken

	Basic Research			Applied Research			Experimental Research		
	Mean	Mean		Mean	Mean		Mean	Mean	
	No interaction	**Interaction**	**P Value**	**No interaction**	**Interaction**	**P value**	**No interaction**	**Interaction**	**P value**
Irish HEI	17.46	17.34	NS	59.89	59.75	NS	22.05	22.06	NS
Irish PRC	17.11	17.55	NS	56.84	61.69	NS	24.12	20.73	NS
Int. PRC	14.73	20.90	0.03	57.93	62.27	NS	26.00	16.79	NS
Int. HEI	18.91	14.27	NS	58.65	62.08	NS	21.48	23.23	NS
Food Co	20.42	15.01	NS	62.32	57.64	NS	15.58	27.32	NS
Food Supp	18.03	14.83	NS	61.69	52.50	NS	19.30	32.67	0.03

Table 4 also shows that those conducting experimental research are significantly more likely than not to interact with food suppliers. This may suggest recognition of the need for commercial orientation by researchers engaged in this type of research. Analysis of interaction by attainment of previous industry experience (table 5) found that those with previous industry experience were more likely to interact with Irish PRCs, food companies and foods suppliers but less likely to interact with international PRCs, international HEIs and Irish HEIs. This could reflect personal relationships established by them in their previous positions and possibly a higher recognition of the need for commercial awareness in research.

Table 5. Relationship between previous industry eaxperience and interaction partner

		Irish HEI's		Irish PRC's		International PRC's		International HEI's		Food Companies	
		No interaction	**Interaction**	**No interaction**	**Interaction**	**No interaction**	**Interaction**	**No interaction**	**Interaction**	**No interaction**	**Interaction**
	Count	14.00	22.00	11.00	25.00	23.00	13.00	20.00	16.00	7.00	29.00
Yes	% with previous industry employmen	38.89	61.11	30.56	69.44	63.89	36.11	55.56	44.44	19.44	80.56
	% within partner activities	36.84	20.56	19.30	28.41	23.71	27.08	24.10	25.81	10.77	36.71
	Count	24.00	85.00	46.00	63.00	74.00	35.00	63.00	46.00	58.00	50.00
No	% with previous industry employmen	22.02	77.98	42.20	57.80	67.89	32.11	57.80	42.20	53.70	46.30
	% within partner activities	63.16	79.44	80.70	71.59	76.29	72.92	75.90	74.19	89.23	63.29
	Count	38.00	107.00	57.00	88.00	97.00	48.00	83.00	62.00	65.00	79.00
	% with previous industry employmen	26.21	73.79	39.31	60.69	66.90	33.10	57.24	42.76	45.14	54.86
	% within partner activities	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Barriers and motivations

Given the level of interaction with the food industry, and the desire to improve it, barriers and obstacles as well as motivations were investigated. The results show that most cited barriers and obstacles were important with all recording a score greater than 2.5 on a 5 point scale where 1= not important and 5 = very important (table 6). The highest score was obtained for insufficient time with the lowest score given to lack of interest. Two of the most important barriers were related to industry, i.e. ‘lack of information about companies’ research activities’ and ‘R&D budgets of potential industry partners too low’. These factors relate to the human capital of both the researcher and industry personnel in terms of networking, communication and technical skills rather than structural problems within the system. Analysis of differences in perceived barriers by PRC vs. HEI researchers found no significant difference with one exception, the lack of specialist technical transfer support. In this instance, researchers from PRCs were more likely to see it as an obstacle than researchers from HEIs.

Table 6. Barriers and obstacles regarding involvement with technology transfer (1=not important, 5=very important)

	Total				PRC's				HEI's				
	Mean	**SD**	**Median**	**n**	**Mean**	**SD**	**Median**	**n**	**Mean**	**SD**	**Median**	**n**	**Pvalue**
Lack of information re: company research activities	3.5	1.8	4	149	3.6	1.9	4	69	3.5	1.8	4	80	NS
Difficulty finding appropriate companies for tech transfer	3.3	1.2	3	144	3.3	1.1	3	68	3.4	1.2	3.5	76	NS
Not enough time	3.8	1.2	4	148	3.7	1.3	4	69	3.9	1.2	4	79	NS
Scientific independence impaired	3.1	1.1	3	145	3.0	1.1	3	67	3.1	1.1	3	78	NS
Hindrance to academic publication activities	3.4	1.2	3	145	3.3	1.2	3	66	3.5	1.1	4	79	NS
Neglect of basic activities	3.0	1.2	3	145	3.2	1.2	3	68	2.8	1.3	3	77	NS
Lack of technical facilities	2.9	1.2	3	142	3.0	1.1	3	67	2.7	1.2	3	75	NS
Lack of interest from industry re: scientific research	3.4	1.1	4	144	3.6	1.1	4	67	3.3	1.1	3	77	NS
Lack of qualified personnel in industry	3.1	1.1	3	145	3.2	1.1	3	68	2.9	1.2	3	77	NS
Lack of specialist tech transfer support	3.1	1.2	3	145	3.6	1.1	4	69	2.8	1.2	3	76	0.000
Nature of research offers limited tech transfer opportunities	3.1	1.2	3	147	3.1	1.2	3	68	3.0	1.2	3	79	NS
Lack of interest re: involvement in commercialisation	2.7	1.3	3	142	2.9	1.2	3	66	2.6	1.3	2	76	NS
Insufficient admin support	3.1	1.2	3	145	3.2	1.2	3	67	3.1	1.3	3	78	NS
Lack of organisational support for commercial application	2.7	1.2	3	142	2.8	1.2	3	67	2.6	1.2	2	75	NS
Research staff lack commercial awareness	3.2	1.1	3	146	3.3	1.0	3	67	3.1	1.1	3	79	NS
Lack of goal alignment re: costs	3.1	1.1	3	142	3.2	1.1	3	67	3.1	1.1	3	75	NS
Lack of goal alignment re: delivery schedules	3.1	1.1	3	141	3.2	1.1	3	67	3.0	1.1	3	74	NS
Low R&D budgets within industry	3.5	1.2	4	141	3.4	1.2	4	66	3.6	1.3	4	75	NS
Lack of confidence in research results	2.9	1.2	3	141	3.0	1.2	3	67	2.8	1.2	3	74	NS
Lack of funding to support researchers to engage in tech transfer	3.4	1.1	3	143	3.5	1.1	4	68	3.4	1.1	3	75	NS

The main motivation for interaction was to secure funds for research, with gaining insight into scientific research, promoting diffusion of research findings, testing application of research and achieving research community recognition close behind (see table 7). Accessing patents and licences and achieving personal financial gain were not regarded as important. Unlike the analysis of differences in perceived barriers by public research centre vs. HEI researchers, analysis of differences in motivations found significant differences on four motivations: create student jobs and internships, secure funds for research, provide real world experience and access patents and licences. In all cases, except the last, the motivations were stronger for researchers from HEIs than from PRCs.

Table 7. Researcher Motivations (1=not important, 5=very important)

	Total					PRC's				HEI's				
	Mean	SD	Median	Mode	n	Mean	SD	Median	n	Mean	SD	Median	n	Pvalue
Test Application of Research	3.7	1.1	4	4	144	3.7	1.1	4	65	3.6	1.2	4	79	NS
Assist RO / HEI Mission	3.4	1.0	4	4	145	3.3	0.8	3	65	3.6	1.1	4	80	NS
Create student jobs & internships	3.1	1.2	3	4	144	2.7	1.1	3	65	3.4	1.2	4	79	0.000
Secure funds for research	3.9	1.1	4	5	146	3.7	1.2	4	66	4.1	1.0	4	80	0.018
Gain insight into scientific research	3.8	1.0	4	4	144	3.8	1.1	4	65	3.9	1.0	4	79	NS
Achieve personal financial gain	2.0	1.2	1	1	143	1.9	1.2	1	64	2.0	1.2	2	79	NS
Achieve industry recognition	3.2	1.2	3	4	145	3.3	1.2	3	66	3.1	1.2	3	79	NS
Achieve research community recognition	3.7	1.1	4	4	145	3.7	1.1	4	65	3.7	1.2	4	80	NS
Achieve recognition from my organisation	3.6	1.1	4	4	145	3.7	1.0	4	65	3.5	1.2	4	80	NS
Support business objectives of industry partners	3.0	1.1	3	3	145	3.2	1.1	3	66	2.8	1.2	3	79	NS
Access company resources	2.8	1.2	3	3	143	2.9	1.2	3	64	2.8	1.2	3	79	NS
Provide real world experiences	3.3	1.2	3	4	147	3.0	1.2	3	67	3.7	1.0	4	80	0.000
Access complementary company expertise	3.3	1.2	3	4	144	3.3	1.2	3	65	3.2	1.2	3	79	NS
Access patents and licenses	1.9	1.0	2	1	143	2.1	1.0	2	64	1.7	1.0	1	79	0.035
Gain practical experience	3.5	1.0	4	4	146	3.4	1.0	4	66	3.5	0.9	4	80	NS
Promote diffusion of research findings	3.8	1.0	4	4	148	3.9	1.0	4	68	3.7	1.0	4	80	NS

Researcher skills

Researchers were asked to indicate on a scale of 1 to 5 the importance of a list of skills thought to be important in terms of technology transfer (1= not important, 5 = very important). They were also asked to rate their own personal proficiency on the same skills on a scale of 1 to 5 (1= low level of proficiency, 5= high level of proficiency). Table 8 shows that the most important skill was communication. The next most highly rated skills were collaborative projects, relationship management, negotiation skills and commercial R&D management. Overall, the fact that the median and mode scores for each category were equal to or greater than 4, suggesting that all were important or very important skills for technology transfer.

Table 8. Rating of importance of skills for technology transfer (1=not important, 5=very important)

	Total				PRC's				HEI's			
	Mean	SD	Median	n	Mean	SD	Median	n	Mean	SD	Median	n
IPR Management	3.8	0.9	4	137	3.8	0.7	4	67	3.8	1.0	4	70
Negotiation Skills	4.0	0.8	4	142	3.9	0.8	4	66	4.0	0.8	4	76
Marketing Skills	3.7	1.0	4	141	3.7	0.9	4	66	3.6	1.1	4	75
Collaborative Project Management	4.3	0.7	4	143	4.2	0.6	4	67	4.3	0.8	4	76
Business Planning	3.7	1.0	4	141	3.7	0.8	4	67	3.6	1.1	4	74
Communication Skills	4.5	0.7	5	144	4.4	0.7	5	68	4.5	0.7	5	76
Relationships Management	4.2	0.8	4	144	4.2	0.7	4	68	4.3	0.8	4	76
Commercial R&D Management	4.0	0.9	4	142	4.0	0.7	4	68	3.9	0.9	4	74
Marketing Research	3.7	1.1	4	143	3.9	0.9	4	67	3.6	1.2	4	76

Some contrast exists when the responses to personal skills (table 9) are compared with the importance of those same skills. For many of the skills identified as important or very important, low levels of personal proficiency exist. For example, the lowest mean score of 2.2 was achieved for marketing research skills proficiency despite achieving a mean score of 3.7 for importance to the technology transfer process.

Table 9. Rating of personal proficiency of skills for technology transfer (1=low level of proficiency, 5=high level)

	Total				PRC's				HEI's				
	Mean	SD	Median	n	Mean	SD	Median	n	Mean	SD	Median	n	Pvalue
IPR Management	2.3	1.0	2	142	2.2	0.9	2	68	2.3	1.1	2	74	NS
Negotiation Skills	3.2	0.9	3	145	3.2	0.8	3	69	3.2	0.9	3	76	NS
Marketing Skills	2.4	1.0	2	145	2.4	0.9	2	69	2.4	1.1	2	76	NS
Collaborative Project Management	3.8	0.9	4	145	3.5	0.9	4	68	4.0	0.8	4	77	0.0
Business Planning	2.7	1.1	3	144	2.8	1.0	3	68	2.5	1.1	3	76	NS
Communication Skills	4.1	0.7	4	145	4.0	0.7	4	68	4.1	0.7	4	77	NS
Relationships Management	3.7	0.9	4	145	3.6	0.9	4	68	3.8	0.9	4	77	NS
Commercial R&D Management	2.5	1.2	2	143	2.5	1.2	2	68	2.5	1.1	2	75	NS
Marketing Research	2.2	1.1	2	141	2.3	1.1	2	66	2.1	1.1	2	75	NS

Discussion

The findings indicated that researchers engage with a wide range of partners to a greater or lesser extent for different purposes. Analysis of differences in the nature and extent of interaction between HEI and PRC researchers, as well as perceived barriers and motivations does not reveal many significant differences. If a linear model of innovation is considered, with PRCs seen as a bridging institution, this would be worrying. However even within a a non-linear model, it is also of concern as a mix of organisational types is vital to maintaining standards of diversity and novelty.

The relatively low level of interaction with the food industry, whilst encouraging, also suggests that current Irish policy focusing on a range of measures to develop collaborative links between industry and academic researchers has yet to bear fruit. The desirability of such a policy is clear as inter-organisational associations between public research institutions and innovative firms, and enabling conditions for effective knowledge creation in public-private collaborations, are the basis for more recent models on innovation including the chain-linked model of Kline and Rosenberg (1986). This has been shown empirically by Harmon et al (1997) when they found that in the majority of cases analysed, technology was transferred not through formal search and arms-length, buy-sell transactions between academic labs and private companies in a linear fashion, but rather through some prior relationships among individuals in a non-linear model. Such models emphasize multi-directional linkages and interdependency between “hard” technology and “softer” issues of people management and information flows (Mitra and Formica, 1997).

While the policy may be clearly formulated, the question of how to solve the task of effective links may not be yet resolved. One area requiring attention is researcher skills. Results from this study identify skills gaps in areas important to the technology transfer process. In particular, the development of skills to build extended networks of relationships both within the business world and the academic community is an important skill that researchers seeking to build a knowledge-based bio-economy need to exhibit. While Irish public funding research programmes are working to redress this somewhat with some current funding within the FIRM programme directed at graduate development, no programme has been targeted at developing skills of existing researchers. This is of considerable importance given the immense store of tacit as well as codifiable knowledge that exists within this group.

However, as more recent models of technology transfer emphasise a bi-directional exchange of knowledge rather than a uni-directional technology-transfer function (Meyer-Krahmer and Schmoch, 1998), such skills are also necessary amongst the business community. The high importance given by researchers to the barrier "lack of information about companies' research activities" in this research emphasises the importance of bi-directional exchange of knowledge. Whilst the development of such skills should be desirable from a company perspective, as interaction with science stimulates firms' innovativeness (it makes a far more diversified range of knowledge sources available to firms than in the case of intra-business interaction (Kaufmann and Tödtling, 2001)) such activity is not always undertaken for a variety of reasons. In further Irish research, the authors of this paper will examine the nature and extent of researcher-industry interactions from an industry perspective as well as their perceived barriers and motivations to help to obtain a better understanding of this other equally important perspective.

However, a final word of caution comes from Kaufmann and Tödtling (2001) who caution against reducing barriers between researchers and industry in a way that minimizes diversity. They claim that "*adjusting the science system's mode of interpretation, decision rules, objectives and specific communicative standards to those of the business sector eliminates exactly the factor which stimulates innovation: diversity*"…"*Bridging – making one system's operation understandable and thus, its output usable for another system – is required*" (Kaufmann and Tödtling, 2001, p802).

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