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TRANSFERRING SCIENCE-BASED TECHNOLOGIES TO INDUSTRY – Does nanotechnology make a difference?*

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ABSTRACT: Nanotechnology has been touted as a general purpose technology (GPT) and engine of growth for the 21th century, following in the footsteps of ICT. Nanotechnology is still in an early phase of development, it is scientist driven and thus largely exogenous to the economy at present. In Finland the interest towards nanotechnology is also growing. This is visible especially through relatively large public R&D expenditures and numbers of scientific publications. A key question for the further development of nanotechnology towards commercialization in Finland, as well as for most other countries active in the field, is the degree to which channels for technology transfer from public research to firms can be established and supported further. This paper uses a new and extensive survey data covering individual Finnish researchers (and inventors) active in the field. It assesses whether nanotechnology brings forth new issues of policy relevance in the various dimensions of technology transfer from the viewpoint of public sector researchers. The results offer new insights into the definition of nanotechnology. Clear differences are also observed in the agents, modes, application and commercialization paths between researchers by the intensity at which they are engaged in nanotechnology. However, the challenges appear to be similar to those related to the transfer of science-based technologies generally. The paper also reports basic frequencies across the survey data as a whole.

KEYWORDS: nanotechnology, Finland, technology transfer, survey data
JEL: O31, O32, O38

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TIIVISTELMÄ: Nanoteknologian veikataan kehittyvän yleiskäyttöiseksi teknologiaksi ja muodostuvan talouskasvun lähteeksi tällä vuosisadalle, seuraten ICT:n jalanjäljissä. Nanoteknologia on vielä suurelta osin varhaisessa tiedelähtöisessä kehitysvaiheessa ja siten tällä hetkellä pääosin talouden kannalta eksogeeninen. Suomessa mielenkiinto nanoteknologiaa kohtaan on kasvamassa, mikä näkyy erityisesti suhteellisen suurissa julkisissa investoinneissa sekä tieteellisten julkaisujen määrässä. Yksi avainkysymys nanoteknologian kaupalliselle kehitykselle Suomessa, kuten myös muissakin maissa, on miten teknologian siirtoa korkeakouluista ja tutkimuslaitoksista yrityksiin saadaan luotua ja tarvittaessa tuettua edelleen. Tutkimus perustuu alalla toimiviin tutkijoihin ja keksijöihin suunnattuun laajaan kyselyaineistoon. Se keskittyy nanoteknologian siirtoon liittyviin erilaisiin ulottuvuuksiin, mahdollisuuksiin ja haasteisiin julkisen tutkimussektorin näkökulmasta. Kyselyn tulokset antavat uusia perspektiivejä nanoteknologian määritelmään. Selviä eroja on havaittavissa toimijoiden, siirtotapojen, soveltuvuusalojen ja kaupallistamisen osalta riippuen siitä, miten intensiivisesti tutkijat ovat tekemisessä nanoteknologian kanssa. Vaikuttaa kuitenkin siltä, ettei teknologian siirtoon liittyvissä haasteissa ole eroa tiedepohjaisten teknologioiden välillä. Lisäksi tutkimus raportoi yleisiä kyselyyn pohjautuvia perusjakaumia.

AVAINSANAT: nanoteknologia, Suomi, teknologian siirto, kyselyaineisto
JEL: O31, O32, O38

CONTENTS

1. INTRODUCTION

1.1. Background

Nanotechnology has been touted as a general purpose technology (GPT) and engine of for the 21th century, following in the footsteps of ICT. At least judged by the growth in public R&D funding into this field in most industrialised countries this might well be the case. Nanotechnology is also generating a range of inventions and patents, it is multipurpose in nature, and is already achieving some complementarities with existing technologies and innovations. Nonetheless, there are also a range of unsolved issues relating to its further development. Nanotechnology is still in an early stage of development, it is very scientist-driven and thus largely exogenous to the economic system. On top of that there are important ethical and regulatory issues to be debated. (Palmberg and Nikulainen, 2006; Ratner and Ratner, 2003).

In Finland the policy interest towards nanotechnology is also growing. Although Finland only contributes with very small amounts to global R&D spending in this field, in relative terms public R&D funding is reaching noteworthy shares. Like elsewhere developments are foremost visible in the growth in nanotechnology-related scientific publications and Finland stands in relative number of publications when compared with some other European countries. However, patenting and innovation activity still lags behind (Table 1).

The further development of nanotechnology in Finland will largely depend on the degree to which existing firms in traditional strongholds areas will be able to identify commercial applications. This will, in turn, depend on the nature of the knowledge base of the related research fields in Finland, and the degree to which channels for technology transfer from public sector research to firms as well as technology-based entrepreneurship can be established and supported further. Further, nanotechnology is also subject to a great deal of hype and unfounded expectations. It is therefore especially important to highlight genuinely new issues and challenges that this technology brings forward in the context of technology transfer.

Table 1. Nanotechnology publications and patents in selected countries

	Absolute numbers		Per capita (thousands)	
	Publications	Inventions (patent families)	Publications	Inventions (patent families)
US	83907	13609	0.29	0.05
Germany	32136	3846	0.39	0.05
Korea	9722	2550	0.2	0.05
Switzerland	6477	627	0.88	0.08
Holland	5282	493	0.32	0.03
Sweden	4300	287	0.48	0.03
Finland	2925	118	0.56	0.02
Denmark	2046	115	0.38	0.02

Source: Palmberg and Nikulainen (2006).

1.2. Aim and structure

Given the rapid growth in public R&D investments and the scientist-based nature of present-day nanotechnology the aim of this paper is to analyse in greater detail the degree to which nanotechnology really presents genuinely new challenges for technology transfer in Finland. As of yet close to nothing is known about the specificities of nanotechnology transfer even though this might be one of the most important issues in the further promotion of the field.

This paper uses a unique survey data, collected at the level of individual researchers and inventors, to provide new insights and thus complement scantly available but growing research on nanotechnology transfer in the economics of technological change (see e.g. Nicolau (2004, 2006) for a conceptual discussion, for empirical contributions see Meyer (2000, 2000a), Bonaccorsi and Thoma (2005), Wang (2006)). More precisely, this paper seeks to highlight the nature of nanotechnology as an object of technology transfer, as well as characteristics of the agents, modes, outcomes, recipients and challenges of the transfer of nanotechnology in a Finnish context. Further it also highlights emerging Finnish application and commercialization paths.

The paper should foremost be read as a descriptive introduction to the survey data at hand as a basis for further in-depth research on nanotechnology transfer. But it also takes on a more analytical approach by pinpointing the degree to which nanotechnology really makes a difference in the above mentioned dimensions of technology transfer.[1] It thereby provides an important contribution to the ongoing discussion about whether `nanotechnology´ merely is a new label for research and development activities that already have been ongoing for decades or whether it really brings forth new issues of relevance for innovation policy.

The paper is structured as follows. The second section provides an analytical framework for the paper by discussing the definition of "technology transfer" and introducing a general model of technology transfer that we use as an organizer for interpreting the results. This section also discusses the methodologies used for identifying nanotechnology-related researchers and inventors in Finland, the survey design and implementation. Section 3 shifts to the empirical analysis, focusing on nanotechnology as the object of technology transfer. Section 4 moves onwards towards investigating the characteristics of research groups as the agents of nanotechnology transfer in Finland, the modes, outcomes, as well as the recipients and challenges of technology transfer. Section 5 concludes the paper with a synthesizing discussion.

2. ANALYTICAL FRAMEWORK AND METHODOLOGY

2.1. Defining technology transfer

The issue of technology transfer from public sector research to industry is closely tied to various conceptualizations of innovation processes, and should be analyzed in this context. The so-called `linear model' of innovation, reflected especially in Vannevar Bush's (1945) seminal report entitled "Science: The Endless Frontier", assumes that public sector research is applied in industry relatively frictionless and one-directionally without the active involvement of firms. Over the years this simplistic view has been overturned by various interactive models of innovation. These models also acknowledge that technology transfer is a two-way street where researchers and firms interact intensively and quite frequently draw on basic research external to the firm (for this discussion see e.g. Kline and Rosenberg (1986); Cohen et al. (2003)).

Definitions of technology transfer also reflect contemporary understanding of innovation as an interactive process. Nonetheless, Bozeman (2000) notes that the litera-

[1] The questionnaire and basic frequencies of the whole survey data are found in Appendix 1 and 2.

ture is abound with a wide range of different definitions due to the multi-dimensionality of this process and difficulties in pinpointing it as a research object amongst other interactive processes during innovation. First of all, consideration must be given to defining the object of technology transfer. Second, consideration must be given to identifying the organizational boundaries that are crossed during transfer of technology. Third, consideration must be given to identifying relevant modes of technology transfer, as well as factors that assumedly have a specific effect on the nature and fluidity of technology transfer. This is naturally also a prerequisite for data collection and analysis.

Defining the *object of technology transfer* is tricky as the term `technology' might cover both scientific research towards advancing technology in general, as well as the knowledge needed to actually use the technology in commercial applications. There is also a large debate about whether knowledge is mainly tacit or codified. The common understanding is that codified knowledge tends to be more footloose and thus easier to transfer, even though tacit knowledge often can be more important, especially when the success of technology transfer is assessed (Gorman, 2002). However, it is questionable whether this distinction really is meaningful as knowledge naturally comprises of both tacit and codified elements.

The practical approach in empirical analysis has been to equate technology with knowledge broadly defined, thus assuming that the term `technology' encompasses not only the scientific and technological entities (i.e. scientific research results, thesis, publications, patents) but also the knowledge of the practical use of technology (Bozeman, 2000). This approach appears to be in line with the switch-over from a linear to an interactive view of the innovation process. Firms rely on scientific research recursively throughout the innovation process when required, and actively seek to define practical usages for scientific research that they aspire to transfer from the public research sector.

Regarding the *organizational boundaries of technology transfer* the term has been used to describe and analyze various different types of interactions ranging from those between developed and less-developed countries, between collaborating or competing private firms throughout strategic alliances, between departments within firms, or between public and private sector actors (Bozeman, 2000). It seems that the identification of generic definition of technology transfer is futile. Instead it is important to derive at a pragmatic and clear definition that communicates with extant research, but nonetheless is compatible with the data at hand and the focus of the specific empirical analysis. Along this line of logic, the definition of technology transfer that we use in this paper is the following:

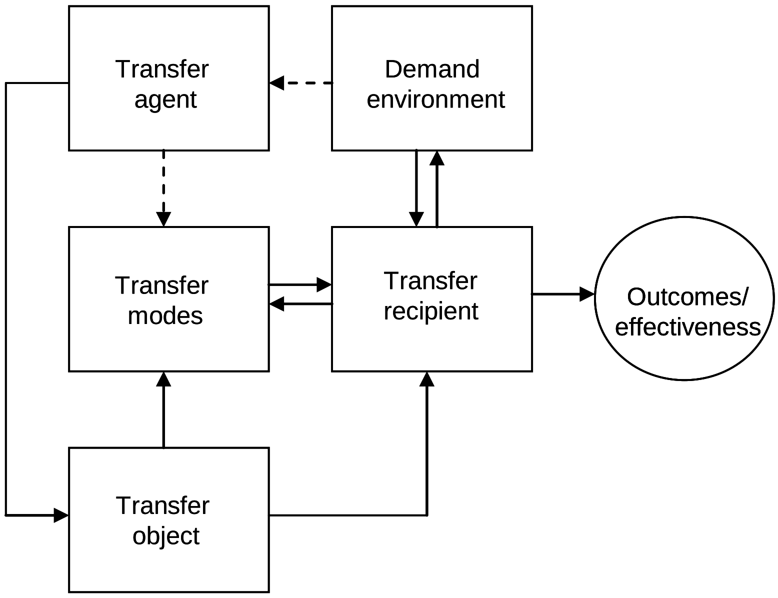
"Technology transfer is the active interaction between public sector researchers, from universities or research institutes, and private sector firms. It covers the transfer of research information and results from the public research sector to private sector firms and the related knowledge in a broader sense, thus including both codified and tacit types of knowledge."

The implicit assumption is that we capture both tacit and codified knowledge related to the research information and results. However, the survey data does not enable us to actually break down the type of knowledge that is transferred by its characteristics. It does not consider the degree to which the transfer of technology also results in tangible outputs from the viewpoint of firms as the receiving parties, e.g. in terms of new processes or products, market shares of economic performance. While the requirement of commercial outputs is not endogenous to our definition, the survey data does contain variables that enable the specification different kinds of achievements as the outcomes of the technology transfer process.

2.2. Dimensions of technology transfer

The ambition of this paper to pinpoint the degree to which nanotechnology really makes a difference requires additional considerations about the various analytical dimensions of technology transfer. The contingent effectiveness model of technology transfer, developed by Bozeman (2000) as a part of his extensive reviews of the literature offers a good starting point for our purposes. Apart from highlighting specificities of the object and organizational boundaries as discussed above, the contingent effectiveness model (CE-model) also considers the agents, modes, recipients and demand environment of technology transfer. As indicated by Figure 1 below it also proposes certain relationships between various dimensions and the outcomes of technology transfer. However, in this paper we aim to highlight specific characteristics of nanotechnology in some of these dimensions while leaving an in-depth analysis of their relationships for subsequent research.

Figure 1. The contingent effectiveness model of technology transfer



Source: Slightly modified from Bozeman (2000).

The *modes of technology transfer* can be numerous. Given the focus of this paper on interactions between public sector researchers and firms, they foremost cover modes of interactions typical to the nature of research work (e.g. participation in conferences and seminars, lectures, supervision of thesis, joint publications, consultancy or joint research projects). Since the advent of innovation policies, the role of orchestrated interaction has also become important, especially in Finland. This type of interaction is typically facilitated through public R&D programs, incubators, science and technology parks and other various intermediaries funded by governments. Finally, technology is transferred through mobility of researchers between university and industry (see e.g. Brennenraedts et al., 2006). This might also occur through joint research- or other facilities that institutionalises mobility.

As the CE- model of technology transfer suggests the characteristic of the *transfer agent* will also contribute to how the transfer object is received by firms. In his review Bozeman (2000) identifies a number of characteristics of research groups at universities and research institutes that are of relevance to briefly touch upon here. First of all, the basic research orientation of groups will directly affect the nature of the transfer object, as is also the case for the scientific disciplinary specialization. Nonetheless, extant research also suggests that problems associated with the transfer of basic research and immature technologies can be partly overcome by organizational arrangements, an active and open-minded culture towards commercialising research, as well as by gatekeepers with both research and business experience (see especially Rahm et al., (1988); Rahm (1994); Allen (1977); Tushman and Katz (1980), MacDonald and William (1994)).

Another important insight from is that university and research institute groups naturally differ in some important ways compared to their counterparts in public research organisations. In particular, university groups might be less interdisciplinary as departments of tradition have been set-up along disciplinary boundaries (Llerena and Meyer-Krahmer, 2003). They will – by default – also give greater emphasis to basic research, as well as scientific publications, conferences and lecturing as modes of interaction with firms as the recipients (the dotted line in Figure 1). Research institutes have a different mission towards technology transfer in this respect and therefore they also tend to be more dependent on external funding. On the other hand, university groups might possess unique and expensive research equipment that firms need. They also have an important resource in their students which will facilitate technology transfer if they are employed by firms after graduation.

In the CE-model of technology transfer characteristics of the *transfer recipient* also matters. In this paper we focus on firms as recipients. From a firm viewpoint extant research suggests that larger firms are in a better position in this respect due to their larger R&D budgets and institutionalised research activities e.g. in central laboratories. Larger firms also tend to be more prone to employ PhDs, some of which might develop into `gatekeepers´ (Harmon et al., (1997)). On the other hand, smaller spin-off firms from the public research sector do also benefit from direct personal contacts to their previous mentors. Smaller and research intensive firms might find greater advantages in locating themselves in the immediate vicinity of universities, and they might take greater advantage of various technology transfer and other intermediating organisations such as science and technology parks (Darby and Zucker, 2003).

The characteristic of the *demand environment* is also an important dimension to consider here as it affects especially the incentives of the transfer recipient but assumedly also the incentives of the transfer agent (the dotted line in Figure 1). The primary issue highlighted by Bozeman (2000) relates to the nature of demand as it affects application and commercialization possibilities of the object of technology transfer through various feedback loops. We will not dwell further into this discussion other than merely noting that researchers' perception of the commercial potential of the technology probably affects their incentives to interact, especially in the case of nanotechnology where researchers play an important role due to the early phase of development of the field.

Finally, we also note that Bozeman (2000) stresses the importance of considering multiple criteria when assessing the *effectiveness of technology transfer*. Nonetheless, this paper merely presenting the intermediate outcomes of nanotechnology transfer, application and commercialization paths descriptively, while an analysis of the effectiveness requires a tighter explanatory approach that we leave for subsequent in-depth research.

2.3. Survey design and practicalities

As the title of this paper suggests the survey focuses on nanotechnology transfer in the broader context of `science-based´ technologies. One of our empirical contributions is to characterize nanotechnology as the object of technology transfer in Finland and we do this in the next section 3 below. For the identification of the survey population we nonetheless had to rely on an empirically relevant definition of nanotechnology that enabled us to identify, in a cruder way, those Finnish researchers and inventors that have had some kind of a documented link to the nanotechnology field. Accordingly we relied on an advanced nanotechnology keyword search algorithm originally developed by Fraunhofer Gesselschaft, Institute Systems and Innovation Research (FhG-ISI) in Germany, to identify nanotechnology-related patents and scientific peer reviewed publications. The algorithm is well established in Europe although it has not, to the best of our knowledge, yet been used before for defining a survey population such as our (see Palmberg and Nikulainen (2006) for further description and display of the algorithm).

The algorithm identified scientific publications and patent families with Finnish researchers and inventors within this field until January 2006. In other words, we apply a broad definition of nanotechnology as it is embedded in the keyword search algorithm at the level of the R&D activities of individual researchers and inventors as these appear in the title, abstract and keywords of the publications and patents. The Finnish nationality of these publications and patents were defined based on the information that at least one of the researchers or inventors had a Finnish affiliation, although foreigners naturally also often participated (for a further discussion on this see Palmberg and Nikulainen (2006)).

It should be stressed that the population of researchers and inventors that we have identified through this methodology are involved in nanotechnology with various intensities. Some have numerous publications that relate to nanotechnology in a strict interpretation of the term, while others might only occasionally have contributed to the field. This is also reflected in the original distribution of publications and patents which is highly left-skewed with a longer left tail of authors having only 1 publication. For identification of the survey population we therefore applied a threshold level of 3 publications (1 publication was considered enough for inclusion in the case of patents). It should also be stressed that the researchers and inventors might have numerous other publications or patents in fields not captured by the nanotechnology keyword search algorithm.

A cumbersome exercise of checking for duplicates and misspelled names was undertaken during February-April 2006, followed by an identification of the contact information using the Internet (email, telephone, address, link to www home page). This exercise resulted in the identification of 1002 individuals for which verified contact information was available. Meanwhile the survey was designed, inspired mainly by the analytical dimensions in the CE-model of technology transfer by Bozeman (2000)(see Appendix 1 for the survey questionnaire). Particular care was taken to enhance the user-friendliness of the survey as well as to facilitate the inclusion also of researchers and inventors at firms, in practice by branching the survey according to whether the respondent mainly conducted research or development activities in a university or research institute setting, or in a firm.

Special consideration was also given to avoid using the term `nanotechnology´ upfront to minimize that definitional ambiguities would affect the respondents perceptions of the various dimensions of technology transfer. Instead we named the survey "Challenges of new research fields in Finland" and only referred explicitly to nanotechnology in the last section of the survey where we enquire about the degree to which the research or development activities of the respondents confer to various definitions of nanotechnology. The survey design was finalized and piloted during August 2006, and sent out as a web-based one during September-November 2006 along with two reminders.[2]

As stated above, this paper provides an analysis of technology transfer from public sector researchers and inventors to firms with a specific focus on the degree to which nanotechnology brings forth new issues and challenges. This means that we primarily rely on the subset of the data that covers public sector researchers (some of which also are inventors and have filed patents) while the data on researchers affiliated to firms is left for later analysis. In the following we will nonetheless present the basic structure of our survey data as a whole (Table 2).

Table 2. The structure of the survey data by affiliation of respondents

		Universities	Research institutes	Firms	Other	Total
No response	N	195	96	94	14	399
Response	N	397	116	79	11	603
		67%	55%	46%	44%	60%
Total	N	592	212	173	25	1002

The response rate after two reminders is 60%, resulting in 603 responses and few item non-responses. This response rate is exceptionally high for a web-based survey and suggests that our efforts in designing the survey and other practicalities were

[2] In addition to the web-based survey we provided English and Swedish language versions in Word-format for 14 individuals who preferred this alternative. We also included an iPod Nano music player lottery as an incentive and promised to send an executive summary of the results to all interested.

worthwhile. A contributing factor for the high response rate was probably also related to the specificities of the target group consisting of junior and senior researchers mostly with less operative responsibilities compared e.g. with R&D managers at firms. This is partly also reflected in the differences in the response rate across the affiliations. University researchers and inventors have the highest rate and this group also constitutes the bulk of the survey data. Researchers and inventors at research institutes and firms have lower response rates, although 55-46% also can be considered as very good.

From Table 2 it is also clear that the survey foremost covers researchers and inventors affiliated to universities as expected given the methodology used in identifying the respondents. The share of respondents affiliated to research institutes and firms is also sufficiently large for comparative analysis across different types of researchers and inventors by these affiliations. Of all respondents affiliated to research institutes 55% work at the Technical Research Centre of Finland (VTT). This should be borne in mind when interpreting the results.

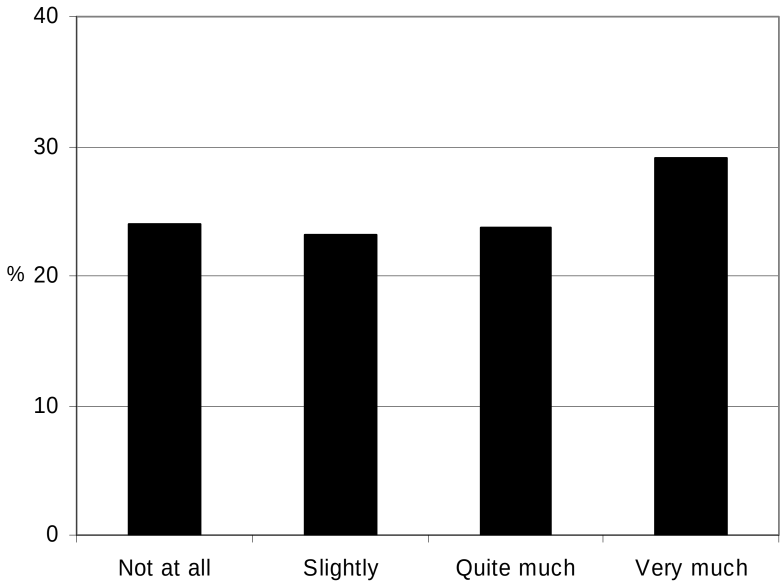
3. FINNISH NANOTECHNOLOGY AS THE TRANSFER OBJECT

3.1. Nanotechnology intensity

With reference to the CE-model we turn to the first issue of characterizing the object of technology transfer by the intensity at which the survey respondents consider themselves involved in nanotechnology. The survey included a question about the compatibility of a definition of nanotechnology commonly used amongst practitioners and policymakers, i.e. the one referred to by the National Nanotechnology Initiative (NNI) in the US (see Appendix 1 and http://www.nano.gov/) with their R&D activities on an ordinal scale from 1 to 4. Figure 2 presents the distribution of the respondents by this question.

Interestingly enough this question splits the data neatly into two equally large subsets (47% less nanotechnology intensive, 52% more nanotechnology intensive). At the extremes 29% consider themselves `very much´ involved in nanotechnology, these researchers and inventors represent the core of nanotechnology in Finland as we have defined it in the survey. Correspondingly, 24% feel that they `not at all´ are involved in nanotechnology. Thus it is clear that the nanotechnology keyword search algorithm also identifies a noteworthy share of researchers and inventors with a rather distant relationship to nanotechnology, or at least which do not communicate with the commonly used NNI definition.

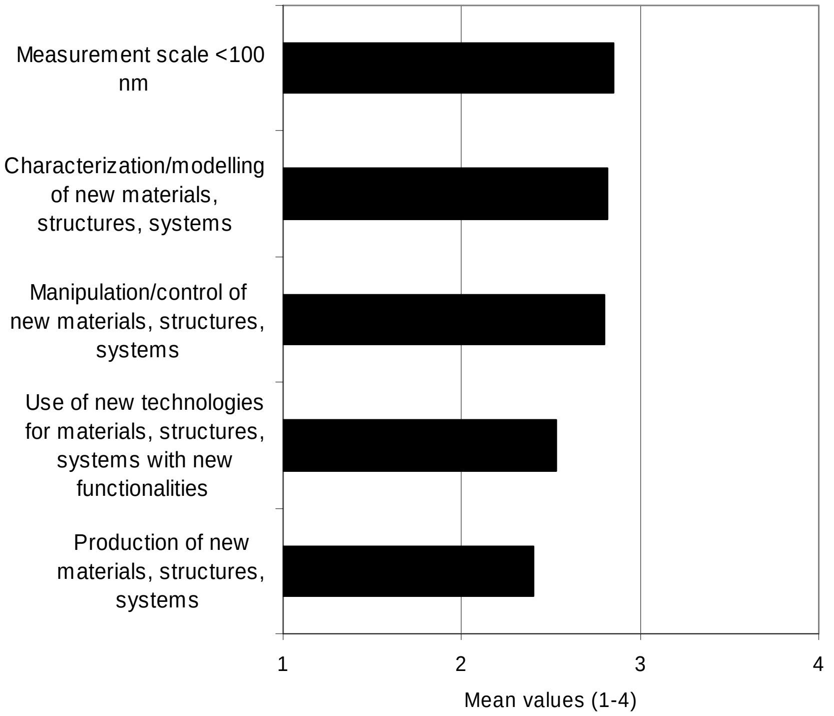
Figure 2. Nanotechnology intensity of respondents



Due to the hype that partly also is associated with nanotechnology it is important to break down the definition somewhat more in order to get a better picture of the content of the R&D that these researchers and inventors are involved in. As a first approximation – pending on the further categorizations – we use five partly overlapping definitions of nanotechnology, again judged on an ordinal scale from 1 to 4 depending on how well they match the research or development content of the respondents.

The first viewpoint captures whether they conduct research or development activities `below the 100 nm measurement scale´. The remaining viewpoints capture the content in terms of basic versus more applied research or development activities, ranging from the `characterization/modelling´ to the `manipulation/control´, `use of new technologies for new functionalities´ of new materials, structures and appliances to the actual `production´ of these. Figure 3 presents the mean value of how well the respective approaches describe the content of the respondents' research content on an ordinal scale from 1 to 4.

Figure 3. Research approach of respondents



The `below the 100 nm scale´ definition appears to be most commonly recognized, followed by the rest in a marginally declining succession of importance when moving towards more applied research or development activities. Interestingly, high scores on all these definitions also correlate positively and significantly ($p<0.01$) with the earlier definition of nanotechnology in Figure 2 above, even tough the correlation coefficient declines somewhat when moving from the `below the 100 nm scale´, `characterization/modelling´ and `manipulation/control´ approaches towards more application oriented research or development activities.

When Figures 2 and 3 are considered jointly the overall impression is that the survey has captured a relevant share of the population of nanotechnology-related researchers and inventors, even though we cannot analyse the coverage explicitly. Further, the definitions of nanotechnology that we have used in the survey appear to be robust. An especially useful characteristic of the split of the data into two equally large subsets by the definition used in Figure 2 is that we can stratify the survey data by nanotechnology intensity, i.e. by `less´ or `more´ nanotechnology. In this way we can live up to the title and aim of this paper and highlight the specificities of nanotechnology across the different dimensions of technology transfer. We will do this with reference to standard chi-square tests across frequencies and t-tests across means of the different subsets. The p-values of these tests are reported throughout.

3.2. Nature of the knowledge base

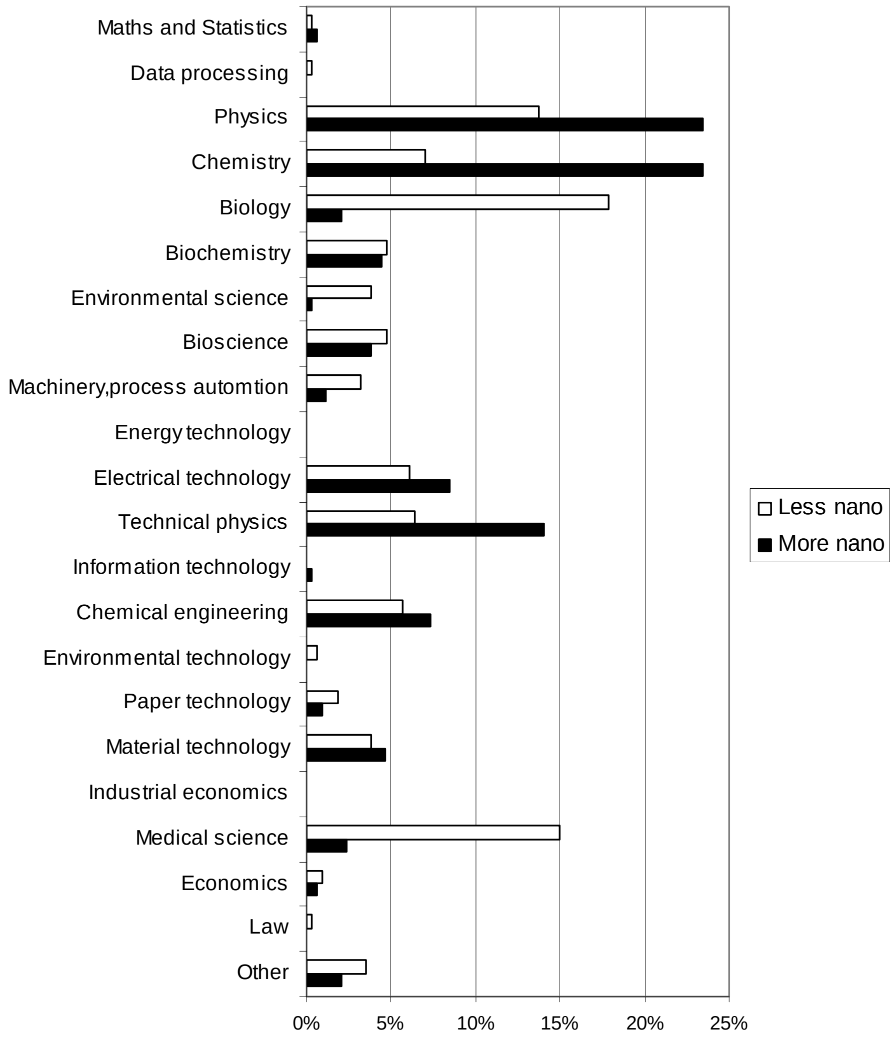
The educational background and professional experience of the researchers and inventors contributes to the nature of the Finnish knowledge base in nanotechnology and thereby also influences the object of technology transfer, especially in terms of its tacit elements. Further, the educational and professional background gives more information on the characteristics of the two subsets of researchers and inventors that we define for the comparative analysis based on their nanotechnology intensity.

Overall the survey apparently targeted senior level researchers and inventors as might be expected given the threshold level of at least three publications that we assigned for inclusion in the survey. Of the total number of respondents 78% hold a PhD degree, while 20% hold a masters degree (the remaining 2% hold a vocational, polytechnic or some other degree). The seniority of the respondents is also reflected in their mean and median age being 44, while they have received their degree on average 13 years ago (mean 13, median 10). The stratification by nanotechnology intensity did not produce any significant differences across respondents in these dimensions and will thereby not have to be considered in interpreting the ensuing results. Figure 4 moves on to the distribution of the educational background of respondents by their highest degree.

Nanotechnology is commonly understood as an interdisciplinary field, mainly mixing various subfields of physics, chemistry, as well as biology (see e.g. Hullmann and Meyer (2003), Heinze (2004), HelsinkiNano (2005)). As expected the fields of physics – including technical physics – and chemistry dominate also in the educational background of these surveyed researches and inventors. What is more surprising is the large share with a biology-related education. When those with a highest degree in biology, biochemistry, and biosciences are added together, the share of biology-related respondents exceeds by far the physics- and chemistry-related ones.

This result is interesting from two viewpoints. First, it underlines further that there is cross-pollination between nanotechnology and biotechnology, perhaps to the degree that we are witnessing the emergence of `nanobiotechnology´ as a new and distinct research field in its own right (compare to Grodal and Thoma (2006); Rafols and Meyer (2006)). Second, it suggests that nanotechnology can potentially find applications also in the biotechnology industry, even though the commercialization of Finnish biotechnology still faces many challenges ahead (Hermans and Kulvik, 2006; Luukkonen and Palmberg, 2007).

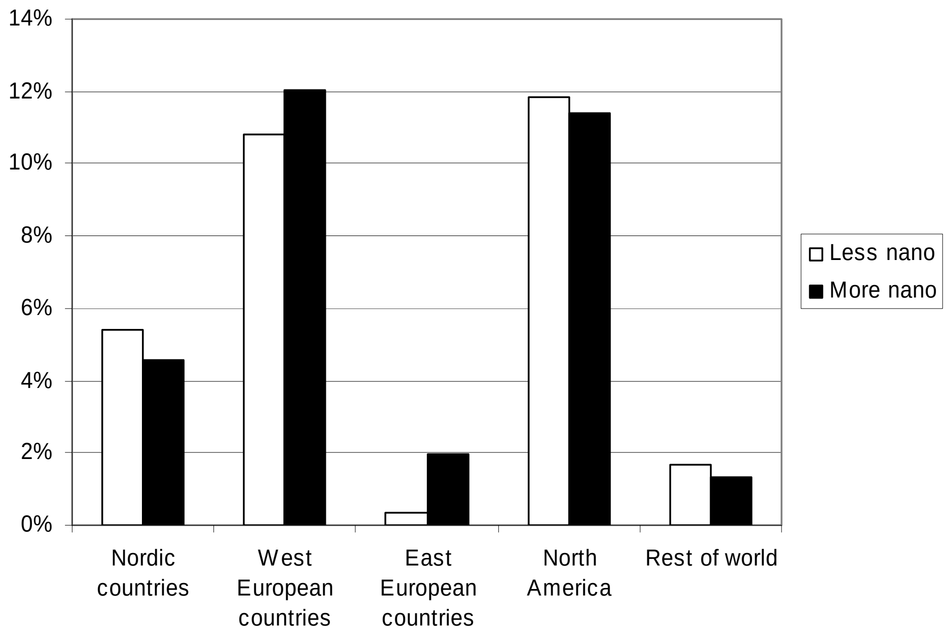
Figure 4. Educational background of respondents



Beyond these general observations, the stratification by nanotechnology intensity introduces noteworthy differences. Those more intensively involved have a stronger background in physics-related fields and chemistry, while those less intensively involved in nanotechnology lean significantly more on biology as well as medical science. In terms of our stratification this implies that our less nanotechnology-intensive subset appears somewhat biased towards researchers and in inventors with a background in biology-related educational disciplines as well as the medical sciences. Biochemistry and bioscience apparently contributes to the field in general irrespective of the nanotechnology-intensity of the respondents.

The professional experience of the respondents is also important to consider. In the survey we included questions on the primary and secondary country of their studies as well as on their work experience. 94% of all respondents have primarily studied for their highest degree in Finland. However, 34% has an experience of spending at least half a year abroad during their studies. These figures do not depend in any noteworthy way on the nanotechnology intensity of the researchers and inventors. Another viewpoint is to look at the distribution of foreign visits of the respondents across geographical regions (Figure 5).

Figure 5. Foreign study visits of respondents



As could be expected European and US research institutions account for the major share of foreign visits, followed by the Nordic Countries. The stratification by nanotechnology intensity does not make a noteworthy difference with the exception that those more intensively involved in nanotechnology have tended to favour European institutions for their visit abroad at the expense of North American ones ($p<0.10$).

In terms of work experience we made a distinction between Finnish and foreign universities or research institutes, small (below 50 employees) and large firms (over 50 employees) in Finland, as well as firms abroad, asking whether the respondents had worked full-time at these respective organisations for at least one year. Table 3 presents the distribution in terms of the share of total respondents that have the corresponding experience by their present primary affiliation.

Table 3. Professional experience by affiliation of respondents

	University	Research institute	Firm	Other
Finnish university or research institute	99%	99%	91%	98%
Foreign university or research institute	65%	61%	49%	31%
Small firm in Finland	24%	15%	82%	33%
Large firm in Finland	28%	40%	87%	43%
Firm abroad	8%	3%	45%	10%

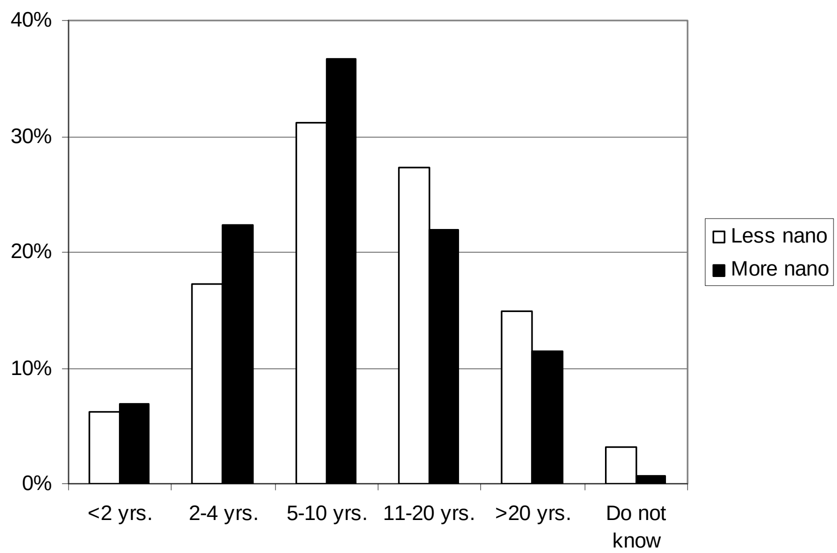
Given that the majority of our respondents are researchers with an academic career path at Finnish universities or research institutes, they have naturally also the most extensive experience of working in these organisations. The relatively active stance that these respondents have taken towards visiting foreign countries during their studies is also reflected in these figures. Further, a noteworthy share has experience of working at larger Finnish firms across the board. By and larger, the stratification by nanotechnology intensity does not produce any noteworthy differences across the subsets.

Based on a survey question we can also locate the respondents to the municipality where they presently work full time (see Appendix 3). The geographical distribution of the respondents appears to match the distribution of well known nano- and biotechnology centres in Finland quite well (see OPM (2005), Palmberg and Nikulainen (2006)).

3.3. Timeframe and drivers for entry

A final perspective on the object of technology transfer is the respondents' drivers and timeframe for entering the present research or development field as this might also contribute to various dimensions of the transferability of nanotechnology to firms. In the survey we asked for the time when the researchers and inventors first initiated research or development activities in their present field on a categorical scale, and enquired about the main motivations for doing so. Turning to the first question in Figure 6 below, the distribution across the entry times suggests that the majority have entered 5-10 years ago or beyond. Nonetheless, when stratified by nanotechnology intensity it is clear that those with a higher intensity also tend to have entered more recently ($p<0.05$).

Figure 6. Time of entry to research field of respondents

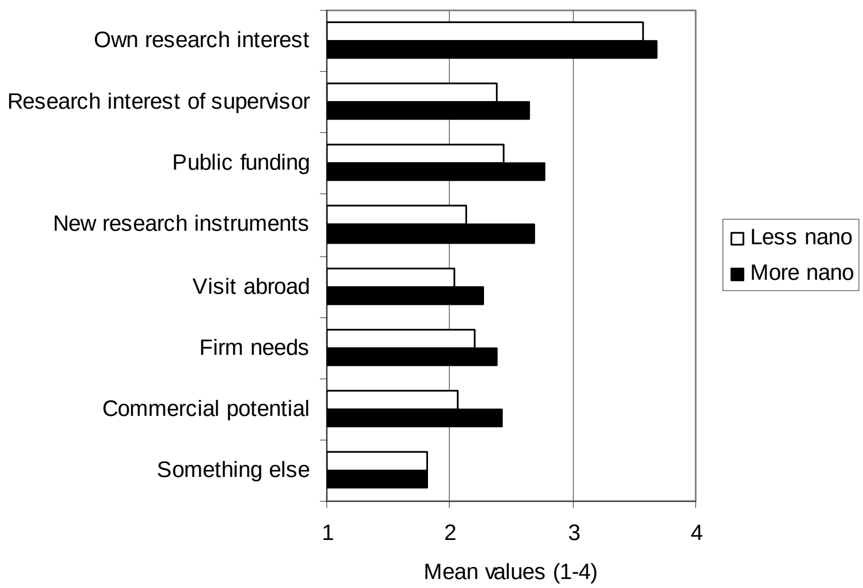


Researchers and inventors have typically entered already many years prior to the launch of the FinNano programs and related policy initiatives in Finland, at a time when the term nanotechnology was not much used. However, those more intensively involved appear to have entered relatively more recently, perhaps also activated by these programs and initiatives. Even though age and entry times naturally relate to each other, this conclusion holds irrespective of age differentials of the respondents as we saw earlier.

The main drivers of the respondents for initiating research or development activities in the field appear as quite common ones, shown in Figure 7 as mean value on an ordinal scale from 1 to 4 by importance (Bozeman, 2002; Lee, 2000; Schartinger et al., 2001). `Own research interest', the `research interest of supervisor' and the `availability of public funding' score high, while `firms needs' and `potentials of commercialisation' appear to matter less. The stratification by nanotechnology intensity does, however, produce significant differences. Those more intensively involved in nanotechnology regard especially the `research interest of supervisor´ ($p<0.01$), `availability of public funding´ ($p<0.01$), `new research instruments´ ($p<0.01$), `visits abroad´ ($p<0.01$), `firm needs´ ($p<0.05$) and `commercial potential´ ($p<0.01$) as relatively more important drivers for initiating research in their field.

Especially the invention of new research instrumentation in the field of microscopy has been considered as defining moments in the development of nanotechnology (Zucker and Darby, 2003). It seems that this is also reflected in our data.

Figure 7. Drivers of entry to research field of respondents



4. AGENTS, MODES AND CHALLENGES OF NANOTECHNOLOGY TRANSFER

4.1. Research groups as transfer agents

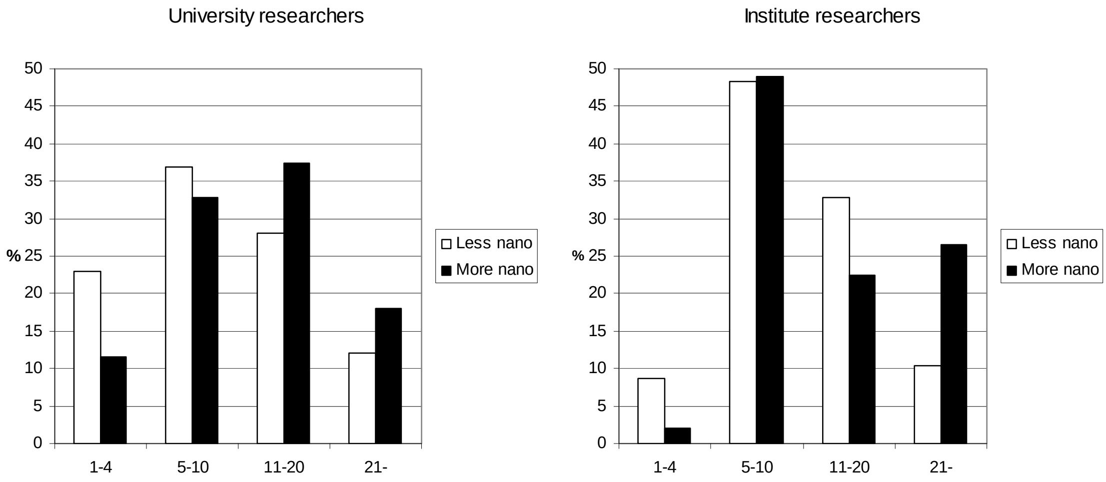
We now move onward from characteristics of Finnish nanotechnology as the object of technology transfer to the actual characteristics, modes and challenges of the process itself. We do this from the perspective of public sector researchers (some of which also are inventors and have filed patents) while excluding the perspectives of firms as well as those with an unknown other affiliation. This reduces the dataset from 603 to 485 respondents (of these 378 are university researchers, 107 are institute researchers).

This focus on public sector researchers is motivated by the fact that the firm perspective on technology transfer is quite different, and thus warrants a separate analysis (the basic frequencies from the firm perspectives is reported in Appendix 2). Moreover, with reference to the discussion about the analytical framework in section 2 we tabulate and analyse the results of the survey across universities and research institutes as affiliations of the respondents that differ in some important ways vis-à-vis technology transfer.

With reference to the CE- model of technology transfer the characteristics of research groups as the agents of this process is one relevant dimension. In the survey we dedicated various questions to this from the viewpoint of the size of groups, their interdisciplinary orientation and funding structures. A research group was defined as the entity where the respondent worked at the time of the survey and that uses common financial, intellectual and material resources.

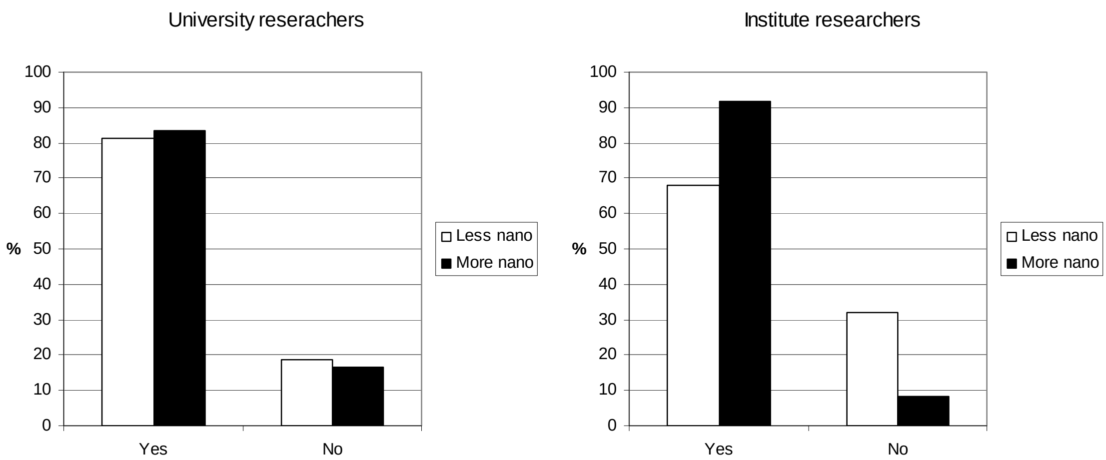
Turning first to the size of research groups it seems that most groups are medium-sized, comprising of 5-20 researchers (Figure 8) across both type of institutions, even though university groups are slightly larger when the two distributions are compared. The stratification by nanotechnology intensity introduces significant differences in this context ($p<0.01$) respectively $p<0.10$). Respondents more intensively involved in the field also tend to work in larger groups, as evidenced especially in the case of university researchers.

Figure 8. Size of research group by affiliation of respondents



One reason for the large size of groups could be that the core of nanotechnology is more interdisciplinary by nature, thus requiring collaboration with a broader range of researchers from different disciplines. Interdisciplinarity is tricky to define in a survey. We defined interdisciplinarity as collaboration within a research group that spans different scientific disciplines, thus excluding external collaboration that all groups assumedly are engaged in. Figure 9 presents the characteristics of research groups from this viewpoint.

Figure 9. Interdisciplinarity of research groups by affiliation of respondents

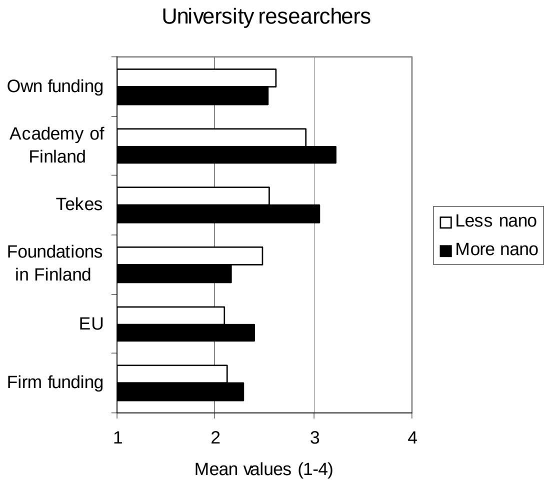


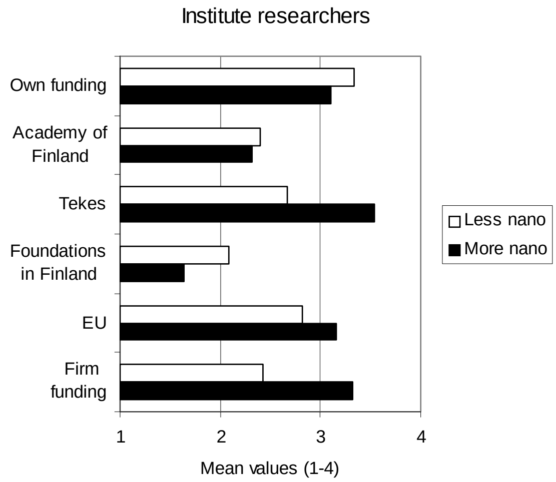
As could be expected an overwhelming majority of all researchers consider themselves working in a research group defined as interdisciplinary, both in the case of university and institute researchers. The stratification by nanotechnology intensity only seems to matter in the case of institute researchers as those more intensively involved in the field also more frequently identify their group as interdisciplinary ($p<0.01$). This result can be taken as some support for the argument by Llerena and Meyer-Krahmer (2003) that research institutes have greater opportunities to conduct interdisciplinary research as they are not constrained by traditional disciplinary boundaries that characterise university departments. However, it does not seem to be the case that an interdisciplinary focus of researcher groups is the primary reason for why nanotechnology-intensive researchers tend to work in larger research groups.

The funding structure of research groups gives indication about the degree to which they are engaged in basic or applied research. Further, the share of firm funding and changes over time points to the degree to which they connect to firms in the first place, even though the presence of firm funding does not automatically imply that technology is actually transferred. Figure 10 gives the mean value of the relative importance that the respondents give on an ordinal scale from 1 to 4 to various sources of funding for funding their research activities.

Hardly surprisingly university researchers give a higher importance to funding by the Academy of Finland and various foundations compared to institute researchers. The institute researchers are more application oriented by default. Correspondingly, institute researchers give a higher importance to Tekes, the EU and firm funding. These comparisons suggest that research institute have been more active towards the R&D programs by the EU when compared with universities. The higher importance given to own funding by institute researchers is primary due to the fact that a majority work at VTT as an institute with a certain share of basic funding by the government.

Figure 10. Sources of funding by affiliation of respondents





Again the stratification by nanotechnology intensity highlights some interesting and significant differences. By and large, those more intensively involved in nanotechnology also give greater importance to funding by the Academy of Finland ($p<0.05$ for university researchers), Tekes ($p<0.01$ for both types of respondents) and the EU ($p<0.05$ for university researchers and $p<0.10$ for institute researchers) compared to the rest. All of these funding institutions have recently launched science or technology programs in the field (the FinNano programs in Finland and the EU framework programs). Accordingly, it seems that those researchers that are more nanotechnology intensive also have been more active vis-à-vis these nanotechnology related public programs. A noteworthy result is also the significantly larger importance that nanotechnology intensive institute researchers give to firm funding ($p<0.01$).

Firm funding gained more attention in the survey. We asked more precisely how large a share firms contributed to the total budget of the research group, as well as how this share had developed during the last three years on a categorical scale (Figure 11). The lesser importance given to firm funding by university researchers is also visible in these figures when comparing to institute researchers. What is interesting, however, is that more nanotechnology intensive researchers report higher shares of firm funding across the board, especially in the range of 26-50% ($p<0.05$ for universities, $p<0.01$ for institutes). The overall impression is that nanotechnology attracts firm funding. Further analysis has to be undertaken in order to assess to what degree these larger shares related to the FinNano and other programs by Tekes, or to direct bilateral funding outside such programs.

When looking at developments during the last three years it is clear that firm funding is on the increase especially for research groups of institute researchers more intensively involved in nanotechnology (p<0.10)(Figure 12). Beyond this, it seems that the share of firm funding has not changed dramatically during the last three years.

Figure 11. Share of firm funding by affiliation of respondents

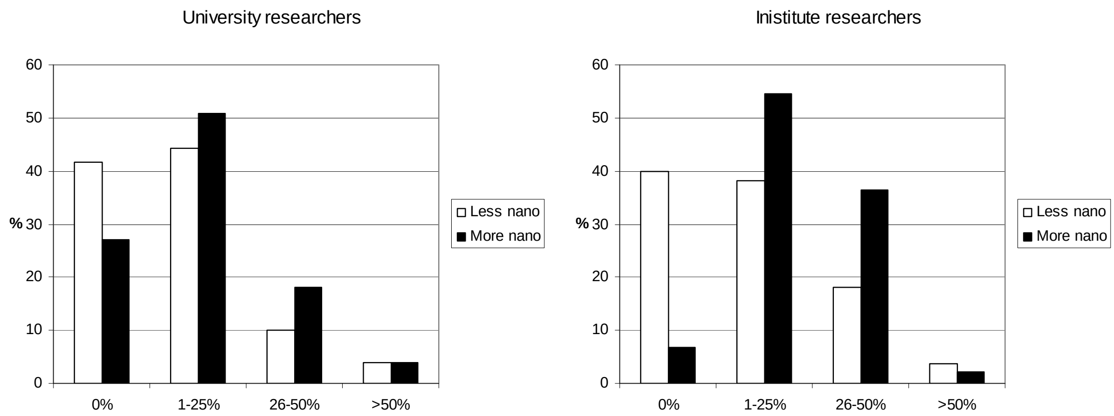
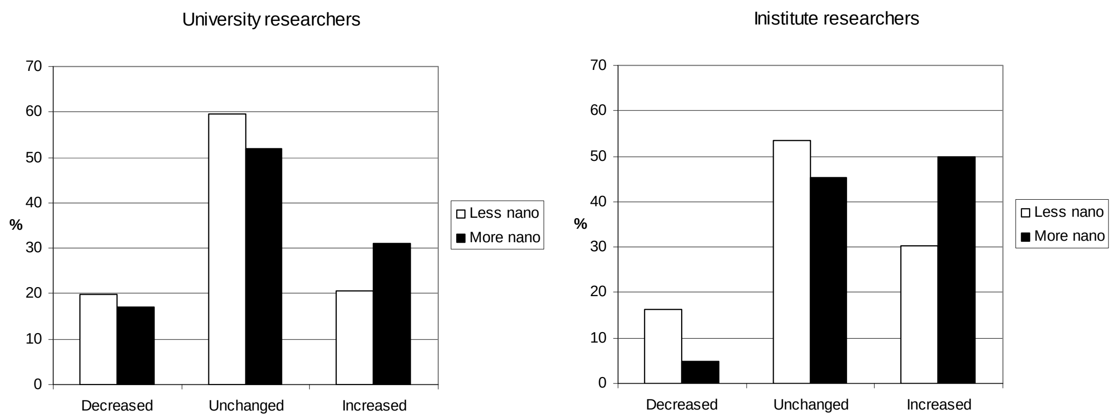


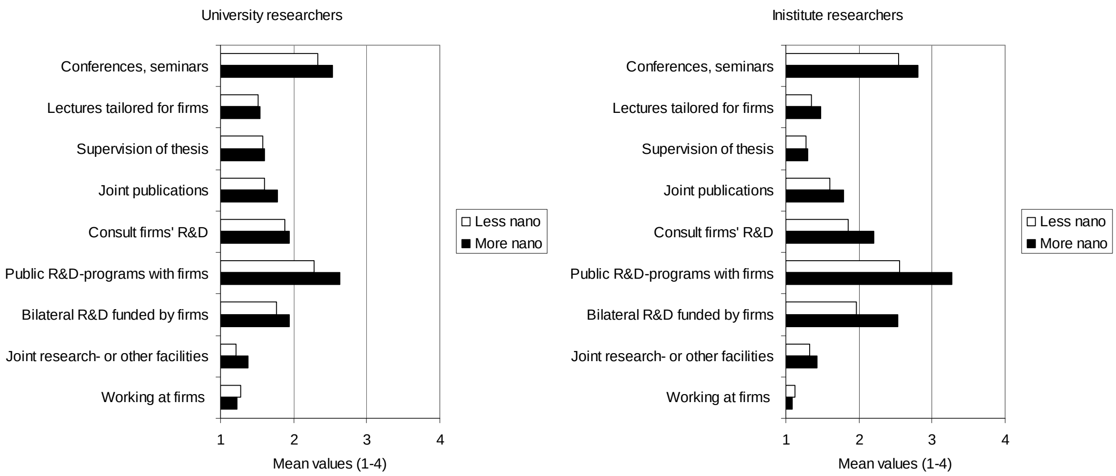
Figure 12. Change in share of firm funding by affiliation of respondents



4.2. Modes and outcomes of nanotechnology transfer

We took particular care in the survey to avoid equating technology transfer modes with formal R&D collaboration based on written contracts, as we wished to cover a broad scale of formal and informal interactions between researchers and firms (compare with Brennenraedts et al. (2006)). Accordingly, we included a question on the degree to which they had been engaged with firms during the last five years in any of the ways displayed in Figure 13 below by degree of frequency, again as mean values on an ordinal scale from 1 to 4.

Figure 13. Technology transfer modes by affiliation of respondents

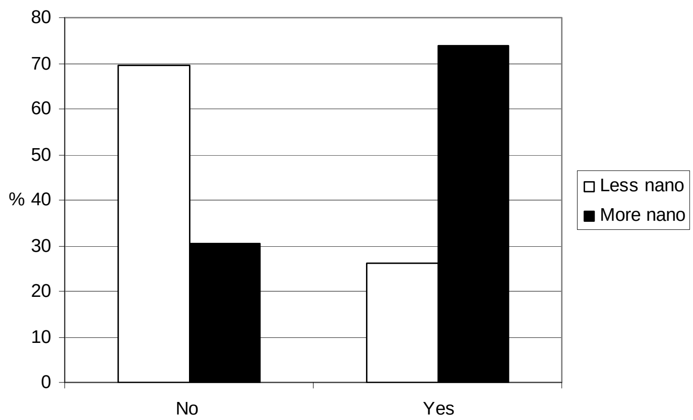


The Figure gives some indication of the degree of interdependency between the researchers and firms as potential or actual recipients of technology transfer. The most frequent modes across both types of researchers are `conferences or seminars´, `public R&D programs´, and `bilateral R&D projects´. Apart from conferences and seminars, all these modes represent quite formal technology transfer.

The stratification by nanotechnology intensity produces significant and interesting differences, suggesting that particularly those more intensively involved in the field also more often engage with firms in the above mentioned ways ($p<0.10$ across the board). Nanotechnology also makes a difference in terms of joint publications involving firms university researchers ($p<0.05$), as well as in terms of having `joint R&D facilities´ ($p<0.05$). Moreover, those institute researchers that are more nanotechnology intensive also tend to have more firm engagement through R&D consulting ($p<0.05$).

The high scores given to `conferences or seminars´ and `public R&D programs´, `bilateral R&D projects´ and `R&D consulting´ might relate to the FinNano programs and thus point to the role of policy in activating researchers vis-à-vis firms. Unfortunately we do not have complete data on all researchers and inventors actually participating in the FinNano-programs. Based on our question whether the respondents had applied for funding from these programs we can nonetheless confirm further that those more nanotechnology intensive appear more active also in this context ($p<0.01$)(Figure 14). Nonetheless, it should be noted that biotechnology has been excluded from these programs. The less nanotechnology intensive subset of respondents has assumedly thereby found these programs less relevant per default.

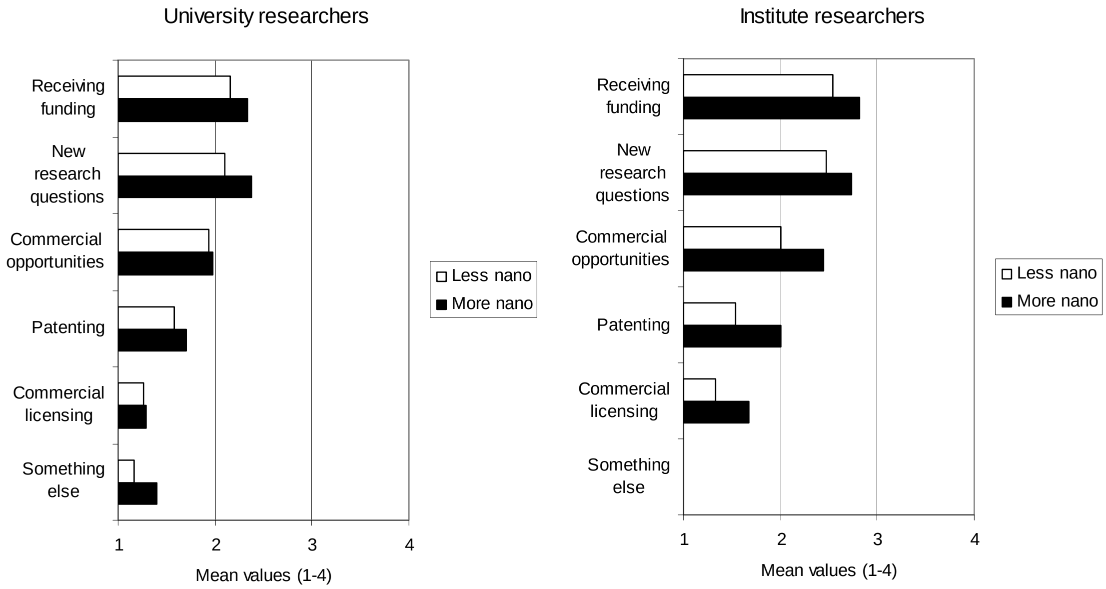
Figure 14. FinNano application



The mode of interaction with firms does not reveal the degree to which researchers actually transfer nanotechnology. Hence, we also included a direct follow-up question on this using an ordinal scale from 1 to 4. As much as 40% of all respondents from universities and research institutes considered themselves transferring `quite a lot´ or `very much´ research information or results to firms, the share being higher for those more intensively engaged in nanotechnology ($p<0.01$). Institute researchers appear to consider themselves especially active in this context since 49% gave high scores. In part this is a natural consequence of the fact that they receive more funding from firms as they are more application-oriented by default. 24% reported no transfer, the share being higher for those less-involved in nanotechnology (30%).

Turning to the outcomes of technology transfer, we took care in including a broad range of different types of outcomes. We asked the respondents to consider how often they had achieved the things showed in Figure 15 as mean values on an ordinal scale from 1 to 4. At the outset it should again be noted that this question naturally falls short of measuring the actual effectiveness of technology transfer as an issue that we can return to later.

Figure 15. Technology transfer outcomes by affiliation of respondents



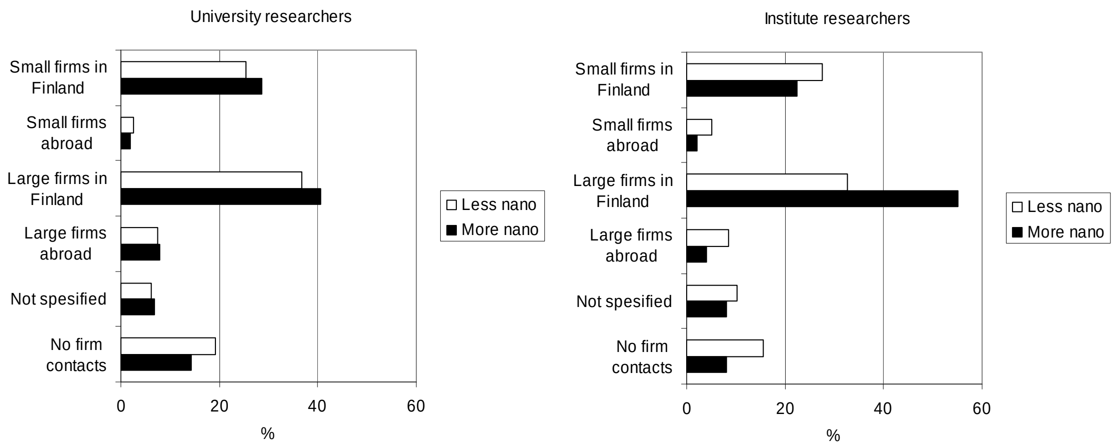
The main outcomes relate to `receiving funding´, `identification of new research questions´ and the `identification of commercial opportunities´, the latter being more important for institute researchers. `Patenting´ and `licensing´ do not appear to be so common amongst these surveyed researchers.

Again some further insights can be gained by comparing across by nanotechnology intensity. University researchers more intensively engaged in the field consider the `identification of new research questions´ as a more frequent outcome ($p<0.05$), while institute researchers clearly do so in the case of `identification of commercial opportunities´ ($p<0.01$), `patenting´ ($p<0.01$) and `licensing´ ($p<0.05$). By and large this appears in line with what was said above relating to the role of research institutes, such as the VTT.

4.3. Nanotechnology transfer recipients and challenges

In the CE-model of technology transfer the characteristics of the transfer recipients are also highlighted as important dimensions in an analysis of technology transfer. The first survey question of relevance here asked about the size of firms that the researchers have primarily been engaged with, distinguishing between firms with less and more than 50 employees. In addition we asked whether the firms were located in Finland or abroad. In Figure 16 we pool both of these questions to arrive at broad classification of firms as the recipients of the research information and results. The distribution is based on the percentage share of respondents that have been engaged with the respective type of firm.

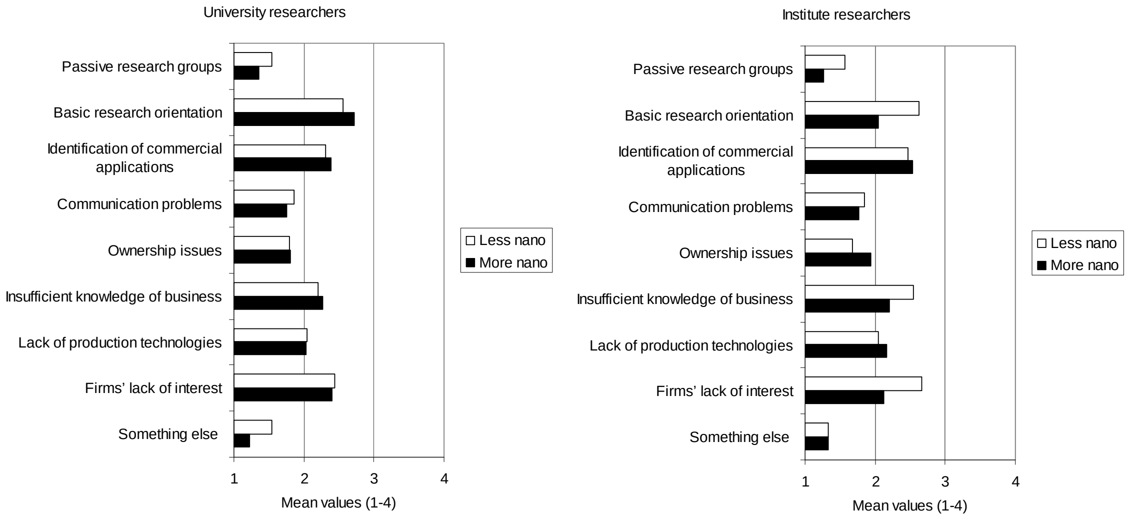
Figure 16. Types of firm engagement by affiliation of respondents



As many as 40% of all respondents primary engage with larger firms in Finland with more than 50 employees. Firms abroad have a far lesser role as transfer recipients, while 7% on average across both subsets mentioned that they have no firm contacts. The stratification by nanotechnology intensity does not alter the results significantly except for institute researchers and their activities vis-à-vis larger firms in Finland. Thus, it seems that the increasing and higher share of funding of nanotechnology intensive institute researchers foremost relates to engagement with larger Finnish firms.

Turning to the perceived challenges, Figure 17 gives the mean value based on an ordinal scale from 1 to 4 of the relative significance that the respondents give to different types of challenges in so far as they have made it more difficult to disseminate research information or results to firms.

Figure 17. Technology transfer challenges by affiliation of respondents



Across both types of institutions the foremost challenges relate to the basic research orientation of nanotechnology and the way in which this hampers the identification of commercial applications. In addition researchers apparently perceive their `insufficient knowledge of business´ as a challenge as well. `Lack of firm interest´ and the `lack of production technologies´ also receive high scores, especially when the partner has been a larger firm. These results confirm further that Finnish nanotechnology presently is very science-based and in an early phase of development even though there are also concrete examples of commercialization paths in Finland (OPM, 2005; Palmberg and Nikulainen, 2006).

In this context the stratification by nanotechnology intensity only produces significant differences for institute researchers. Those more intensively involved actually view the `basic research orientation of the field´, `insufficient knowledge of business´, and `firms lack of interest´ as a lesser challenge ($p<0.05$, $p<0.05$, respectively $p<0.01$). Moreover, both university and institute researchers that are more nanotechnology intensive consider their research groups as less passive in terms of firm interactions.

Overall, the impression is thereby that higher nanotechnology intensity does not offer noteworthy different challenges with respect to technology transfer in generally. Further, the challenges highlighted here seem to be broadly similar to what the literature on technology transfer tends to highlight also in other countries (see e.g. Bozeman (2000); Meyer (2000a); Schartinger et al. (2001); Cohen et al. (2003)). In fact, it seems that high nanotechnology intensity appears to imply that researchers in Finland also are more closely oriented towards firms at the outset. This is an issue worthy of further analysis later one.

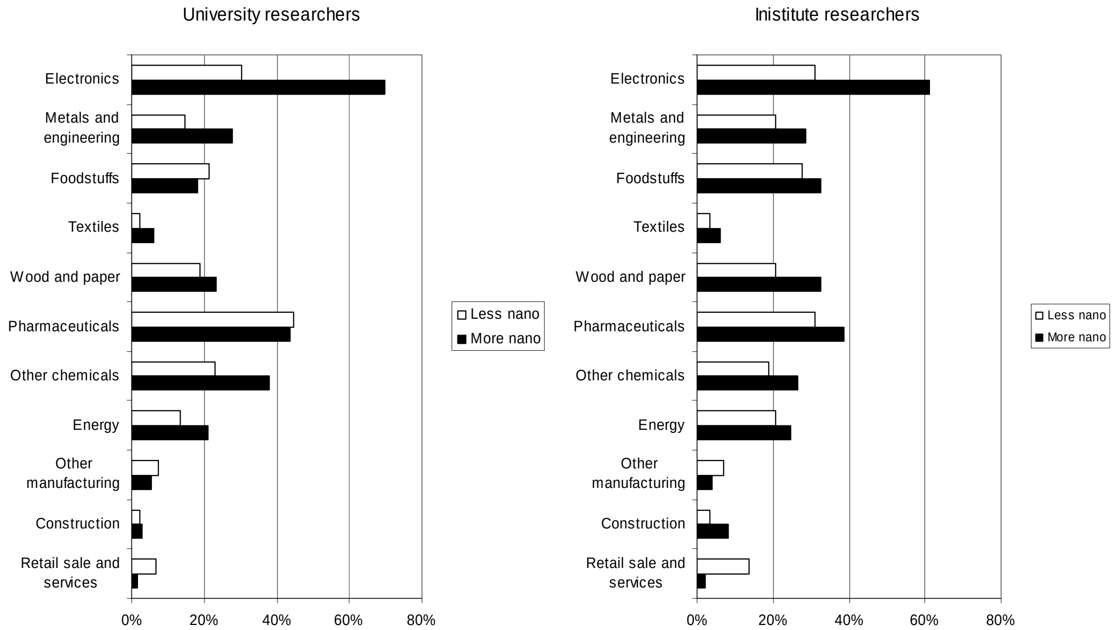
The location of researchers at science parks, technology centres or the like probably also affects the challenges and opportunities that they perceive. We covered this by asking whether such intermediating organisations had been important for facilitating interactions with firms. Out of all respondents 15% considered intermediating organisations as beneficial, while 22% of the more nanotechnology intensive ones did so. University researchers considered intermediating organisations as more beneficial. This is probably also due to the fact that these are more geographically dispersed with units more frequently located in these organisations when compared with research institutes.

4.4. The demand environment: application and commercialization paths

Given the early phase of development of nanotechnology the demand environment for technology transfer is difficult to quantify. In the CE-model of technology transfer the demand environment is foremost considered to affect the incentives of the recipients of technology transfer, while we also claim that it will affect the transfer agents. Given our focus on public sector researchers in this paper the closest we could come to covering this was to ask about industries and commercialization durations that the researchers considered as viable when moving from research and development activities towards commercialization.

Turning first to application industries, we asked the respondents to choose three industries that hold the most potential for the application of their research or development activities using a standard industry classification scheme (Figure 18). The industries referred to most frequently include `electronics´, `pharmaceuticals´, and `other chemicals´, the latter two receiving particularly much mentioning by those university researchers who are more intensively involved in nanotechnology.

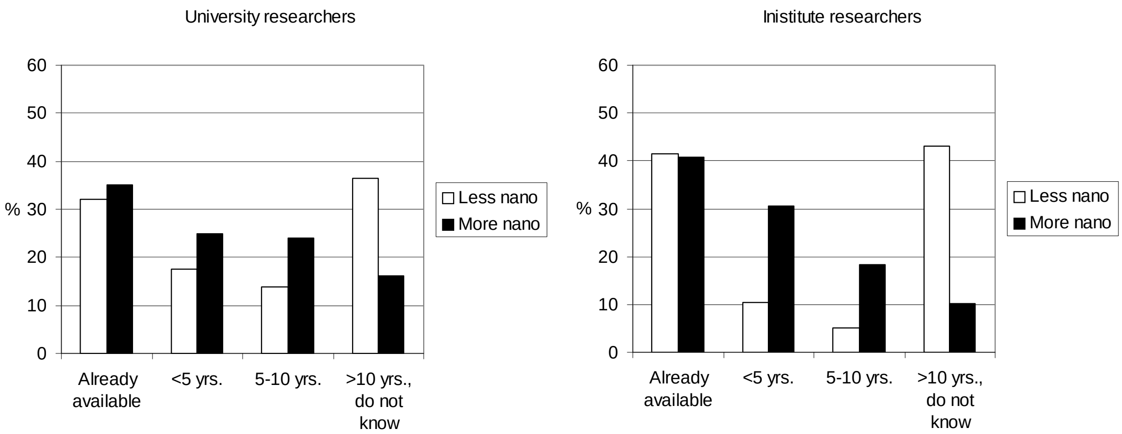
Figure 18. Application industries by affiliation of respondents



The high frequency of pharmaceuticals is interesting and compatible with the fact that a large number of the researchers also have an educational background in medical science as well as biology-related fields. It highlights yet further the cross-pollination between nano- and biotechnology, but also points to policy challenges due to the fact that there is a lack of larger pharmaceuticals firms in Finland with resources to commercial biopharmaceuticals internationally (see Hermans and Kulvik (2006); Luukkonen and Palmberg (2007) for the case of biotechnology). The high frequency of electronics reflects traditional Finnish strongholds in this industry, not least through the success of Nokia and the telecommunications industry. Apart from these high-technology industries the \`metals and engineering´, \`foodstuffs´, \`wood and paper´ and \`energy´ industries also receive relatively much mentioning.

Concerning the commercialization durations we made a distinction between the expected time to commercial applications of the research and development field in general and the specific area in which the respondents worked within. In this way we hoped to get some insights about the global developments as well as the position of Finnish research areas against these global developments. Figure 19 presents the distribution of the durations in general on a categorical scale as the number of expected years to significant international commercial applications. The expected durations appear as surprisingly short as a significant share of the respondents already now identify existing commercial application. On the other hand, a large share either does not know or expects applications to emerge only beyond 10 years. This category represents respondents that have a rather uncertain perception of the duration, or work in research fields that are not intended for commercialization in the first place.

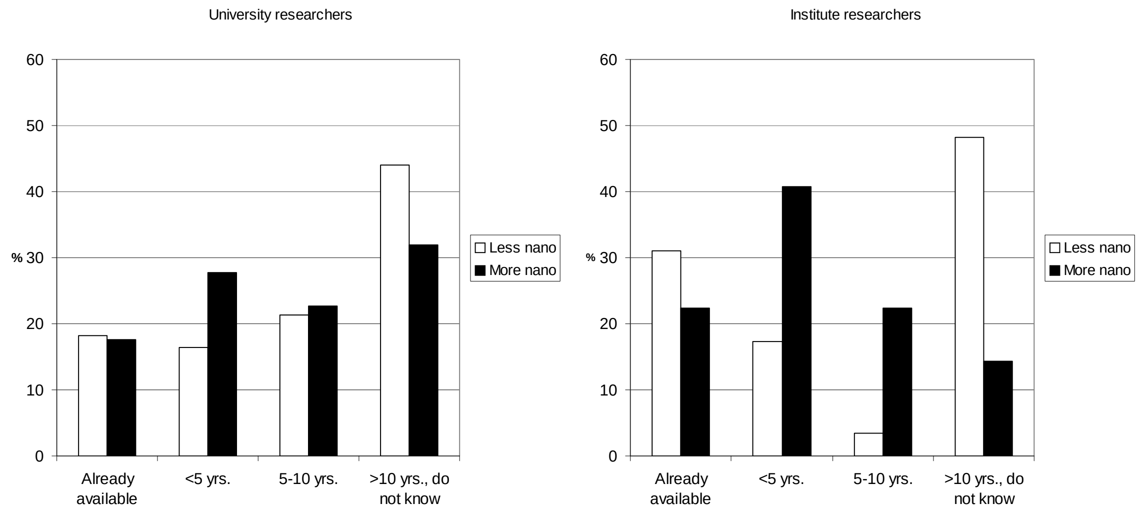
Figure 19. Commercialisation durations in general by affiliation of respondents



The stratification by nanotechnology intensity produces significant differences as those that are more nanotechnology intensive tend to have a more optimistic view on the durations ($p<0.01$ for both groups). The differences appear especially pronounced amongst institute researchers where a higher nanotechnology intensity dramatically reduces the share of unknown durations, or durations expected to last beyond 10 years. One reason for these clear differences assumedly relates to the observation made earlier that a much larger share of the less nanotechnology intensive researchers have an educational background in biology and the medical sciences. In so far as these apply nanotechnology in drug design and development, the fact that various clinical trials prolong commercialisation durations in the pharmaceuticals industry surely is reflected here (for an analysis of commercialisation durations across industries see Palmberg (2006)).

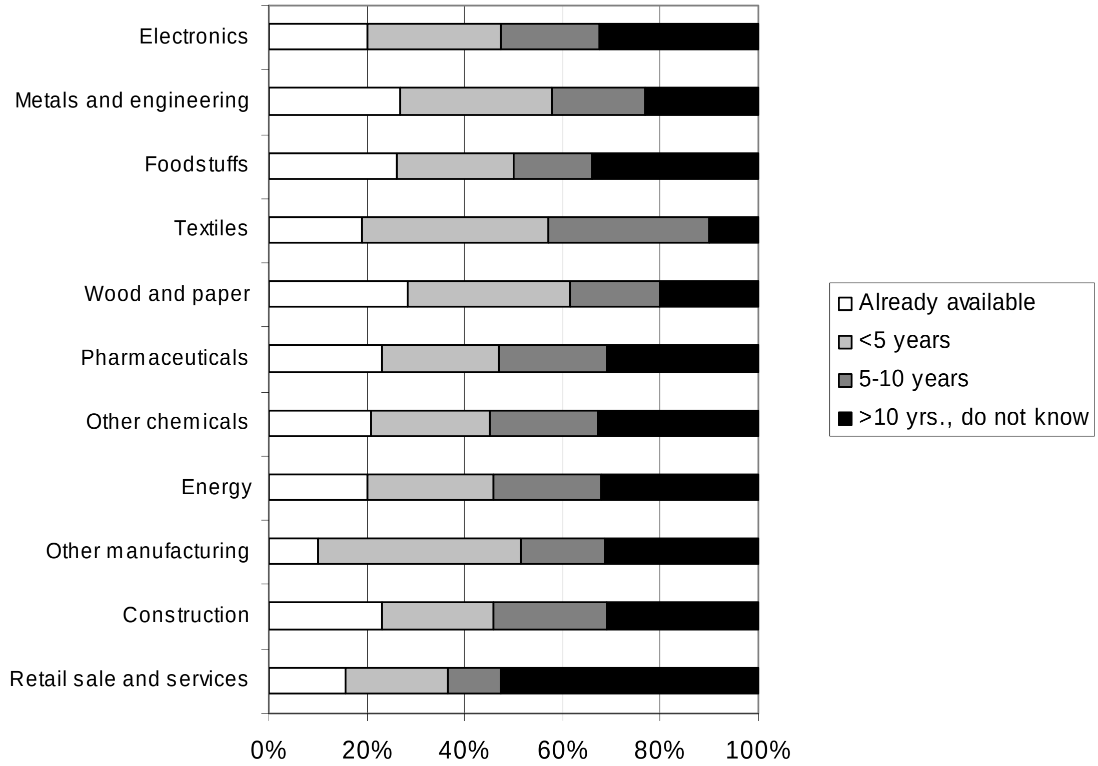
When turning to the expected time to commercialization of the specific area in which the respondents worked within at present a different distribution emerges (see Figure 20 where the durations are on the same categorical scale as above). The share of respondents suggesting longer commercialization durations increases especially for those who do not know or expect durations of 10 years or more. Correspondingly, the share that already now identifies commercial breakthroughs is smaller when compared with the durations in general. By and large, it thereby seems that the researchers have a less optimistic viewpoint on the time to commercialization of their own research when compared with the situation for their field as a whole more generally.

Figure 20. Commercialisation durations of own research by affiliations of respondents



The stratification by nanotechnology intensity produces significant differences as those that are more nanotechnology intensive tend to have a more optimistic view about the durations ($p<0.05$ for university researchers, $p<0.01$ for institute researchers). The difference is particularly clear for institute researchers where the share of respondents who do not know or expect 10 years or more drops very noteworthy by higher nanotechnology intensity. These results might again relate to the \`biology and medical science effect´ discussed above. Further insights can be gained by cross-tabulating these durations with the frequency of potential application industries. We do this in Figure 21 by distinguishing for each industry the share of respondents expected different durations along the same categorical scale.

Figure 21. Commercialisation durations of own research by application industries



Interestingly the respondents identifying applications in R&D-intensive industries such as pharmaceuticals, chemicals and electronics also tend to expect longer or unknown commercialization durations for their own research compared with the situation in the more traditional industries such as metals and engineering, foodstuffs, pulp & paper, energy and construction. In other words, even though the largest share of all respondents identify high-technology industries as the most potential ones for commercial applications many traditional industries might offer quicker commercialization paths. This observation is an important one to be explored in greater depth.

5. A SYNTHESISING DISCUSSION

This paper uses a unique survey data, collected at the level of individual researchers and inventors, to provide new insights into specificities of the transfer of nanotechnology from the public research sector to industry in Finland from the viewpoint of public sector researchers. It uses the contingent effectiveness model, developed by Bozeman (2000), as an analytical organizer to highlight various dimensions of technology transfer while leaving their relationship causalities for further analysis. The survey and this paper are motivated by the high commercial expectations that nanotechnology raises in Finland, as well as in most other industrialized countries, even though the field still is very scientist-driven. One key issue for the further development of nanotechnology in Finland is therefore whether channels for nanotechnology transfer can be established and supported further for the commercialization, as well as the general development, of the related sciences and technologies.

The contingent effectiveness model identifies the nature of the object, agents, modes, recipients and the demand environment of technology transfer as the key analytical dimensions. Nanotechnology is an elusive *object of technology transfer* due to definitional ambiguities. The survey data has an origin in an advanced nanotechnology keyword search algorithm that identified Finnish researchers and inventors in the field through their publication and patenting profiles. Slightly more than half of all respondents did indeed consider themselves involved in nanotechnology by the common definitions that we used, even though a noteworthy share of 24% identified no involvement. This result partly questions the reliability of the keyword search algorithm that is often used as science and technology indicators for nanotechnology developments. Nonetheless, it might also underline further the definitional ambiguities; some respondents simply do not communicate with the term `nanotechnology´ even though their research or development activities focuses on nanoscale phenomena.

In this paper we have capitalized on the split of the data into two equally large subsets of respondents by their nanotechnology involvement, or intensity, to consider whether "nanotechnology makes a difference" in the various dimensions of technology transfer.[3] These subsets of respondents do not differ to any greater extent in terms of their educational level, professional experience or age. However, those more intensively involved in nanotechnology have a stronger educational background in physics-related fields and chemistry, while the less involved ones lean relatively more on biol-

[3] It is important to note once more that we took particular care in the design of the survey to avoid using the term 'nanotechnology' upfront and only referred to it in the last section of the questionnaire to minimize that definitional ambiguities and hype would affect the respondents' perceptions of the various dimensions of technology transfer.

ogy as well as medical science. This result underlies the cross-pollination between nano- and biotechnology, while also suggesting that the core of Finnish nanotechnology nonetheless mainly draws on physics and chemistry. These differences in the educational background of the two subsets of respondents have to be borne in mind when interpreting the results.

To what degree then "does nanotechnology really make a difference" in the various dimensions of technology transfer? It is clear that the difference can only be one of degree as we, after all, all comparing two subsets of public sector researchers with a similar background in natural sciences. Despite this we can pinpoint numerous interesting differences which are relevant to consider for policymakers. In terms of the *agents of technology transfer*, the more nanotechnology intensive research groups are larger in size and they tend to be somewhat more interdisciplinary, especially in the case of research institutes. They also give greater importance to funding by the Finnish Funding Agency for Technology and Innovation (Tekes) and have higher shares of firm funding. The overall impression is thus that these research groups are attracting somewhat more firm funding and, at least by this criterion, appear well positioned as agents of nanotechnology transfer.

The share of firms funding is naturally an important although not sufficient condition for technology transfer. *Technology transfer* can take various *modes* and produces various *outcomes*, some of which are more conductive for the process and its effectiveness than others. Generally speaking, conferences and seminars, public R&D programs, and bilateral R&D projects are the most common modes of interactions with firms, while securing research funding and identifying new research questions or commercial opportunities are the most common outcomes. However, the modes mentioned above are especially prevalent amongst the more nanotechnology intensive researchers. Further, they have been more active in applying for funding from the public FinNano-programs, both of which are dedicated explicitly to nanotechnology. They also give a better self-assessment of their technology transfer attempts. Hence, the overall impression is that this subset of more nanotechnology intensive respondents takes a more active stance towards technology transfer, engage more often with firms through conferences, seminars, public R&D programs and bilateral R&D projects, and also attract more firm funding.

Why is a higher nanotechnology intensity associated with a more active stance towards technology transfer? At least two interpretations seem relevant here. A first interpretation is that the FinNano programs have indeed activated the intended transfer agents, contributed to increasing their share of firm funding, and facilitated increasing interactions between public sector research and R&D in firms. A definite assessment of this interpretation would nonetheless require more detailed data on the actual participation of researchers and inventors in the FinNano programs as well as previous related programs in the past. A second interpretation is that there might be some unaccounted differences between the two subsets of respondents that drive the results, one such differences relating to the higher share of less nanotechnology intensive respondents that have a degree in biology or the medical sciences.

In terms of *transfer recipients and challenges* the large majority of the surveyed public sector researchers and inventors interact with Finnish rather than foreign firms, especially in the larger firm size cohorts. The major challenges relate to the basic research orientation of their fields, to challenges in identification of commercial applications, their lack of business or market skills, or the lack of firm interest. All of these challenges appear as characteristic of the scientific and technological fields that we covered through the survey as nanotechnology intensity does not differentiate across the two subsets of respondents. Hence, nanotechnology does not appear to bring forth new specific challenges on top of those that characterize the transfer of science-based technologies to firms in general. Due to the wide range of applicability and multipurpose nature of nanotechnology further analysis of the challenges is nonetheless needed by a breakdown of subfields, application industries and commercialization paths. The viewpoint of firms should also be included.

With reference to the contingent effectiveness model, this paper also incorporates the *demand environment* of technology transfer as perceived by public sector researchers. The potentials of widespread commercial application of nanotechnology are reflected in the broad range of industries that the respondents highlighted. Nonetheless, the more R&D intensive electronics, metal and engineering, pharmaceuticals and other chemicals industries stand out amongst those respondents that are more nanotechnology intensive. The high frequency for the electronics industry is probably a natural consequence of Finnish specialization in information and communication technologies (ICT), not least through Nokia. The high frequency for pharmaceuticals is interesting and underlines further the cross-pollination between bio- and nanotechnologies. It points to policy challenges in commercialization due to the fact that there is a lack of larger pharmaceuticals firms in Finland with resources to bring bio-nano-pharmaceuticals all the way to the markets.

In terms of expected durations from research to commercial breakthroughs, a higher nanotechnology intensity produced more optimistic judgements amongst the respondents. This seems to be a direct consequence of the fact that commercialisation per default are longer or uncertain for biology-related research and especially bio-pharmaceutical products as these have to undergo various clinical trials prior to market introduction. Sometimes commercialization might not even be intended depending on the specific type of research field that the respondent works within. However, an especially interesting result is that those respondents identifying applications in the more traditional and less R&D-intensive industries of metals and engineering, foodstuffs, pulp & paper, energy and construction also expected shorter commercialisation durations. The specificities of the underlying factors that explain these differences are important to analyse further given the strong competitiveness that Finland also has in many of the more traditional `low-tech´ industries.

REFERENCES

Allen, T. (1977). "Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information Within the R&D Organization."

Bonaccorsi, A and Thoma, G. (2005). “Scientific and Technological Regimes in Nanotechnology: Combinatorial Inventors and Performance. LEM Working Paper Series, 2005/13.

Bozeman, B. (2000). "Technology transfer and public policy: a review of research and theory." Research Policy 29(4-5): 627-655.

Brennenraedts, R., Bekkers, R. and Verspagen, B. (2006). "The different channels of university-industry knowledge transfer: Empirical evidence from Biomedical Biomedical Engineering." Ecis Working Paper.

Bush, V. (1945). "The Endless Frontier, Report to the President on a Program for Postwar Scientific Research."

Darby, M. and L. Zucker (2003). "Grilichesian Breakthroughs: Inventions of Methods of Inventing and Firm Entry in Nanotechnology." NBER Working Papers 9825.

Gorman, M. (2002). “Types of Knowledge and Their Roles in Technology Transfer”. Journal of Technology Transfer, 27, 219-231.

Ministry of Education (OPM) (2005). "Spearheads of Nanosciences in Finland." (Nanotieteen keihäännkärjet Suomessa), in Finnish.

Grodal, S. and G. Thoma (2006). "Cross Pollination in Science and Technology: The Emergence of theNanobio Subfield." unpublished manuscript.

Harmon, B. et al. (1997). "Mapping the university technology transfer process." Journal of Business Venturing 12(6): 423-434.

Heinze, T. (2004). "Nanoscience and Nanotechnology in Europe: Analysis of Publications and Patent Applications including Comparisons with the United States." Nanotechnology, Law and Business 1(4).

HelsinkiNano. (2005). "Final report."

Hermans, R. and Kulvik, M. (2006). "Sustainable biotechnology development - New insights from Finland." ETLA, B:217.

Hullmann, A. and M. Meyer (2003). "Publications and patents in nanotechnology - An overview of previous studies and the state of the art." Scientometrics 58(3): 507-527.

Kline, S. and Rosenberg, N. (1986). "An Overview of Innovation." in The Positive Sum Strategy: Harnessing Technology for Economic Growth National Academy of Sciences (NAS).

Lee, S. (2000). “The Sustainability of University-Industry Research Collaboration: An Empirical Assesment”. Journal of Technology Transfer, 25, 111-133.

Llerena, P. and Meyer-Krahmer, F (2003). "Interdisciplinary Research and the Organization of the University: General Challenges and a Case Study." In Geuna, A., Salter, A and Steinmuller, E (eds.).Science and Innovation, Edward Elgar.

Luukkonen, T. and Palmberg, C. (2007). “Living up to the Expectations Set by ICT? The Case of Biotechnology Commercialisation in Finland”. Forthcoming in Technology Analysis and Strategic Management.

Macdonald, S and Williams, C (1994). "The Survival of the Gatekeeper." Research Policy 23(2): 123-132.

Meyer, M. (2000). "Does science push technology? Patents citing scientific literature." Research Policy 29(3): 409-434.

Meyer, M. (2000a). "Hurdles on the way to commercialising novel technologies - The case of nanotechnology." Helsinki University of Technology, Institute of Strategy and International Business. Working Paper Series 2000:1.

Nicolau, D. (2004). "Challenges and Opportunities for Nanotechnology Policies: An Australian Perspective." Nanotechnology Law & Business 1(4).

Nicolau, D. (2006). "Innovation and Knowledge Transfer in Emerging Fields: The Case of Nanotechnology in Australia." Nanotechnology Law & Business 2(4).

Palmberg, C. (2006). "The sources and success of innovations – Determinants of commercialisation and break-even times". Technovation 26, 1253-1267.

Palmberg, C. and Nikulainen, T. (2006). "Industrial Renewal and Growth through Nanotechnology ? - An Overview with Focus on Finland." ETLA Discussion paper 1020.

Rahm, D., Bozeman, B. and Crow, M. (1988). "Domestic Technology Transfer and Competitiveness: An Empirical Assessment of the Roles of University and Government Research and Development Laboratories." Public Administration Review 48(6).

Rahm, D. (1994). "U.S. Universities and Technology Transfer: Perspectives of Academic Administrators and Researchers." Industry and Higher Education 8(2).

Ratner, M. Ratner, D. (2003). "Nanotechnology: a gentle introduction to the next big idea”. New Jersey: Prentice Hill.

Rafols, I. and Meyer, M. (2006). "Knowledge-sourcing strategies for cross-disciplinarity in bionanotechnology". 2006 Annual Conference, Technology Transfer Society: Next Generation Innovation: New Approaches and Policy Designs, September 27-29, 2006, Atlanta, USA.

Schartinger, D, Schibany, A and Gassler, H. (2001). "Interactive Relations Between Universities and Firms: Empirical Evidence for Austria." The Journal of Technology Transfer V26(3): 255-26

Tushman, M. and Katz, R. (1980). "External Communication and Project Performance: An Investigation into the Role of Gatekeepers." Management Science 26(11): 1071-1085.

Wang, J. (2006). ”Resource spillover from academia to nanotech industry: Evidence from start-up enterprises. 2006 Annual Conference, Technology Transfer Society: Next Generation Innovation: New Approaches and Policy Designs, September 27-29, 2006, Atlanta, USA.

Cohen, W, Nelson, R, and Walsh, J. (2003). ”Links and impacts: the influence of public research on industrial R&D“. In Geuna, A, Salter, A & Steinmuller, E (eds.), “Science and Innovation: Rethinking the Rationales for Funding and Governance”. Cheltenham, UK: Edward Elgar.

APPENDIX 1. THE QUESTIONNAIRE

1. Education and professional experience

1.1. At which level have you received your highest degree?

- Vocational degree ☐
- Polytechnic degree ☐
- University degree ☐
- Licentiate or doctoral degree ☐
- Other ☐

1.2. In which fields have you received your highest degree?

Natural Sciences

- Mathematics or statistics ☐
- Data processing ☐
- Physics ☐
- Chemistry ☐
- Biology ☐
- Biochemistry ☐
- Environmental sciences ☐
- Biosciences ☐

Engineering

- Machinery, process or automation ☐
- Energy technology ☐
- Electrical engineering ☐
- Technical physics ☐
- Information technology ☐
- Chemical engineering ☐
- Environmental technology ☐
- Pulp- and paper technology ☐
- Material technology ☐
- Industrial economics ☐

Others

- Medical sciences ☐
- Economics ☐
- Law ☐
- Some other ☐

1.3. Have you primarily studied for your highest degree in Finland?

- Yes ☐
- No ☐

If no, in which country?

1.4. Did you visit any other country for at least half a year during your studies?

- Yes ☐
- No ☐

If yes, in which country(ies)?

1.5. Which year did you receive your highest degree?
Year:

1.6. Which year are you born?
Year:

1.7. How many scientific publications do you have in peer reviewed journals?

0	☐
1-9	☐
10-19	☐
20-49	☐
50-100	☐
100+ publications	☐

1.8. In how many patent applications have you participated in?

0	☐
1-5	☐
6-10	☐
11-20	☐
20+ publications	☐

1.9. In which of the following organisations have you worked full-time for at least one year?

	Yes	No
A Finnish university or research institute	☐	☐
A foreign university or research institute	☐	☐
A firm in Finland with less than 50 employees	☐	☐
A firm in Finland with more than 50 employees	☐	☐
A firm abroad	☐	☐

1.10. Where do you presently work full-time?

At a university	☐
At a research institute	☐
In a firm	☐
Somewhere else	☐

1.11. In which municipality do you presently work full-time?

2. Activities of the research group

Please answer this section and the next (sections 2 and 3) only if you primarily at present work at a university, research institute or the equivalent. If you work in a firm please go directly to section 4. In this section we refer to the research group where you work at present. By a research group we refer to the entity, or team, where you work that uses common financial, intellectual and material resources.

2.1. What is the size of your research group?

1-4	☐
5-10	☐
11-20	☐
21-100	☐
100+ persons	☐
I don’t know	☐

2.2. Does your group conduct inter-disciplinary research?

We define inter-disciplinarity as collaboration within your group that spans different scientific disciplines.

- Yes ☐
- No ☐
- I don't know ☐

2.3. What has been the importance of the following sources of funding for your research group during the last five years? With importance we refer to the relative share of the source for funding the research. (On a scale 1-4, where 1 = Not important at all and 4 = Very important)

	1	2	3	4	I don't know
Own funding	☐	☐	☐	☐	☐
Academy of Finland	☐	☐	☐	☐	☐
Tekes	☐	☐	☐	☐	☐
Public or private foundations in Finland	☐	☐	☐	☐	☐
EU	☐	☐	☐	☐	☐
Other foreign public sources	☐	☐	☐	☐	☐
Firm funding	☐	☐	☐	☐	☐

2.4. According to your approximation, what is the share of funding from firms out of the total for your research group presently?

- 0% ☐
- 1-25% ☐
- 26-50% ☐
- over 50% ☐
- I don't know ☐

2.5. How has the share of firm funding for your research group changed during the last three years?

- Declined ☐
- Stayed constant ☐
- Increased ☐
- I don't know ☐

3. Knowledge transfer

From this section onwards section we refer to your own personal research and related activities (i.e. not to your research group). R&D stands for Research and Development.

3.1. Have you been engaged with firms in any of the following ways during the last five years? (On a scale 1-4, where 1 = Not at all and 4 = Very much)

	1	2	3	4	I don't know
Conferences or seminars	☐	☐	☐	☐	☐
Lectures tailored for firms	☐	☐	☐	☐	☐
Supervision of thesis of employees of firms	☐	☐	☐	☐	☐
Joint publications with firm representatives	☐	☐	☐	☐	☐
Consultation related to firms R&D	☐	☐	☐	☐	☐
Public R&D-programs involving firms	☐	☐	☐	☐	☐

Bilateral R&D projects funded by firms	☐	☐	☐	☐	☐
Joint research- or other facilities	☐	☐	☐	☐	☐
Temporary employment at firms	☐	☐	☐	☐	☐
In some other way	☐	☐	☐	☐	☐

If in 'some other way', could you please briefly specify?

3.2. Do you transfer research information/results to firms (through other means than publications)?

- Not at all ☐
- A little ☐
- Quite a lot ☐
- Very much ☐
- I don't know ☐

3.3. How have your possible firm contacts mainly been made?

- Through a contact made by yourself ☐
- Through contact made by your research group ☐
- Through a contact made by firms ☐
- I do not have firm contacts ☐

3.4. Have the following types of intermediating organisations been important for facilitating contacts with firms: innovation- or technology centres, firm incubators, technology transfer offices etc.?

- Yes ☐
- No ☐
- I don't know ☐

3.5. If you are engaged with firms in your research activities, how often have you achieved the following things? (On a scale 1-4, where 1 = Never and 4 = Very often)

	1	2	3	4	I don't know
Receiving research funding	☐	☐	☐	☐	☐
Identification of new research questions	☐	☐	☐	☐	☐
Identification of commercial opportunities	☐	☐	☐	☐	☐
Patenting of research results	☐	☐	☐	☐	☐
Commercial licensing of research results	☐	☐	☐	☐	☐
Something else	☐	☐	☐	☐	☐

If 'something else', could you please briefly specify?

3.6. To what degree do the following things make it more difficult to disseminate research results to firms? (On a scale 1-4, where 1 = Not at all and 4 = Very much)

	1	2	3	4	I don't know
The passiveness of your research group	☐	☐	☐	☐	☐
The basic research orientation of your field	☐	☐	☐	☐	☐
Challenges in the identification of commercial applications	☐	☐	☐	☐	☐
Communication problems with firms	☐	☐	☐	☐	☐
Ownership issues relating to research results	☐	☐	☐	☐	☐
Insufficient knowledge of business or markets	☐	☐	☐	☐	☐

Lack or underdevelopment of production technologies	☐	☐	☐	☐	☐
Firms' lack of interest	☐	☐	☐	☐	☐
Something else	☐	☐	☐	☐	☐

If 'something else', could you please briefly specify?

3.7. Would you be interested in founding a firm based on your research?

- Yes ☐
- No ☐
- I have already founded a firm ☐
- I don't know ☐

3.8. With firms of what size have you primarily been in contact with through your research?

- Firms with less than 50 employees ☐
- Firms with more than 50 employees ☐
- I do not have contacts with firms ☐
- I don't know ☐

3.9. With firms from which country have you primarily been in contact with?

- Finnish firms in Finland ☐
- Foreign firms in Finland ☐
- Firms abroad ☐
- I don't know ☐

4. Knowledge transfer

Please answer this section only if you primarily at present work in a firm. Otherwise, please go directly to section 5. In this section we mainly refer to your own personal R&D- activities (i.e. not to the activities of your firm in general). R&D stands for Research and Development.

4.1. Have you been engaged with universities or research institutes in any of the following ways during the last five years? (On a scale 1-4, where 1 = Not important at all and 4 = Very much)

	1	2	3	4	I don't know
Conferences or seminars	☐	☐	☐	☐	☐
Supervision of thesis of employees of firms	☐	☐	☐	☐	☐
Joint publications with researchers	☐	☐	☐	☐	☐
Consultation related to R&D	☐	☐	☐	☐	☐
Public R&D-programs	☐	☐	☐	☐	☐
Bilateral R&D projects funded by your firm	☐	☐	☐	☐	☐
Joint R&D- or other facilities	☐	☐	☐	☐	☐
Employment at a university or research institute	☐	☐	☐	☐	☐
In some other way	☐	☐	☐	☐	☐

If in 'some other way', could you please briefly specify?

4.2. Do you receive information/results from universities or research institutes that are relevant to the R&D of your firm?

- Not at all ☐
- A little ☐
- Quite a lot ☐
- Very much ☐ I don't know ☐

4.3. How have your possible contacts with universities or research institutes mainly been made?

Through a contact made by yourself	☐
Through a contact made by your firm	☐
Through a contact made by universities or research institutes	☐
I do not have such contacts	☐

4.4. When in contact with universities or research institutes in your R&D activities, how often have you achieved the following things? (On a scale 1-4, where 1 = Never and 4 = Very often)

	1	2	3	4	I don't know
Identification of new product ideas	☐	☐	☐	☐	☐
Patenting of research results	☐	☐	☐	☐	☐
Commercial licensing of research results	☐	☐	☐	☐	☐
Recruitment of new personnel	☐	☐	☐	☐	☐
Development of existing products or processes	☐	☐	☐	☐	☐
Development of completely new products or processes	☐	☐	☐	☐	☐
Something else	☐	☐	☐	☐	☐

If 'something else', could you please briefly specify?

4.5. To what degree do the following things make it more difficult to receive research results from universities or research institutes? (On a scale 1-4, where 1 = Not at all and 4 = Very much)

	1	2	3	4	I don't know
The passiveness of researchers	☐	☐	☐	☐	☐
The basic research orientation of the research field	☐	☐	☐	☐	☐
Challenges in identifying commercial applications	☐	☐	☐	☐	☐
Communication problems	☐	☐	☐	☐	☐
Ownership issues relating to research results	☐	☐	☐	☐	☐
Researchers' insufficient knowledge of business	☐	☐	☐	☐	☐
Lack or underdevelopment of production technologies	☐	☐	☐	☐	☐
Something else	☐	☐	☐	☐	☐

If 'something else', could you please briefly specify?

4.6. What is the nationality of universities with whom you primarily are in contact with as a part of your R&D activities?

Finnish universities	☐
Foreign universities	☐
I don't know	☐

4.7. With which types of research institutes are you primarily engaged with as a part of your R&D activities?

VTT	☐
Other research institutes in Finland	☐
Research institutes abroad	☐
I don't know	☐

4.8. To what degree does your firm have R&D collaboration with other firms?

- Not at all ☐
- A little ☐
- Quite a lot ☐
- Very much ☐
- I don’t know ☐

5. Content and origins of research or development activities

5.1. How well do the following atom- or molecular-level approaches describe the content of your present research or development activities? (On a scale 1-4; 1 = Not at all and 4 = Very well)

	1	2	3	4	I don't know
The measurement scale is often below 100 nanometres	☐	☐	☐	☐	☐
Characterisation and modelling of new materials, structures or systems	☐	☐	☐	☐	☐
Manipulation and/or control of new materials, structures, systems	☐	☐	☐	☐	☐
Use of new technologies for materials, structures, systems with new functionalities	☐	☐	☐	☐	☐
Production of new material, structures, systems	☐	☐	☐	☐	☐

5.2. To what degree does the following definition of nanotechnology describe the content of your present research or development work?

“Research and development at the atom-, molecular- or macromolecular level of 1-100 nanometres, at which new or existing structures, appliances or systems are used in a controlled setting in order to give them new characteristics and functions due to their small size”

- Not at all ☐
- Slightly ☐
- Quite much ☐
- Very much ☐
- I don’t know ☐

5.3. What is the content of your primary research or development activities at present (a brief description)?

5.4. Have you participated in a project that has applied for funding from the FinNano programs of Tekes or the Academy of Finland?

- Yes ☐
- No ☐
- I don’t know ☐

5.5. When did you, for the first time, initiate research or development activities in your present primary research field?

- Less than 2 years ago ☐
- 2-4 ☐
- 5-10 ☐
- 11-20 ☐
- 20+ years ago ☐
- I don’t know ☐

5.6. How important have the following drivers been for initiating research in your present primary research or development field?
(On a scale 1-4, where 1 = Not important at all and 4 = Very important)

	1	2	3	4	I don't know
Your own research interest	☐	☐	☐	☐	☐
The research interest of your supervisor	☐	☐	☐	☐	☐
Availability of public funding	☐	☐	☐	☐	☐
Possibility to use new research instruments	☐	☐	☐	☐	☐
Visit at a firm/university/research institute abroad	☐	☐	☐	☐	☐
The needs of firms	☐	☐	☐	☐	☐
The potentials for commercialisation	☐	☐	☐	☐	☐
Something else	☐	☐	☐	☐	☐

If 'something else', could you please briefly specify?

6. The application of research or development activities

6.1. Choose at the most three industries that hold the most potential for applications of your research or development activities?

- Electronics ☐
- Metals and engineering ☐
- Foodstuffs ☐
- Textiles- and clothing ☐
- Wood and paper ☐
- Pharmaceuticals ☐
- Other chemicals ☐
- Energy ☐
- Other manufacturing ☐
- Construction ☐
- Retail sale and services ☐
- Others ☐

6.2. Approximately when can significant international commercial applications be anticipated for the research or development field you work within?

- Applications are already available ☐
- Within 5 years ☐
- 5-10 years ☐
- Over 10 years ☐
- I don't know ☐

6.3. Approximately when could your own research or development activity lead to first commercial applications?

- Applications are already available ☐
- Within 5 years ☐
- 5-10 years ☐
- Over 10 years ☐
- I don't know ☐

6.4. Which is your standpoint regarding the following claims concerning the development of your research field in Finland? (On a scale 1-4; 1 = Strongly disagree and 4 = Agree very much)

	1	2	3	4	I don't know
There is a need for new interdisciplinary post-graduate education programs	☐	☐	☐	☐	☐
Researchers do not have knowledge about the protection of intellectual property	☐	☐	☐	☐	☐
Researchers participate actively in international networks	☐	☐	☐	☐	☐
Public funding is directed to the correct research fields	☐	☐	☐	☐	☐
The lack of standards is a bottleneck for developments	☐	☐	☐	☐	☐
The commercial interest of large firms is declining	☐	☐	☐	☐	☐
The expectations of financiers regarding commercialisation times are realistic	☐	☐	☐	☐	☐
The university is better at commercialising research results than researchers	☐	☐	☐	☐	☐

APPENDIX 2. BASIC FREQUENCIES OF WHOLE SURVEY DATA

1.1. Level of highest degree	%	Obs.
Vocational	1.34	8
Polytechnic	0.67	4
University	19.90	119
Doctoral	77.59	464
Other	0.50	3
Total	100.00	598

1.2. In which fields have received the highest degree?

1.2. Mathematics and statistics	%	Obs.
Yes	0.50	3
No	99.50	600
Total	100.00	603
1.2. Data processing	%	Obs.
Yes	0.17	1
No	99.83	602
Total	100.00	603
1.2. Physics	%	Obs.
Yes	20.40	123
No	79.60	480
Total	100.00	603
1.2. Chemistry	%	Obs.
Yes	16.92	102
No	83.08	501
Total	100.00	603
1.2. Biology	%	Obs.
Yes	10.45	63
No	89.55	540
Total	100.00	603
1.2. Biochemistry	%	Obs.
Yes	4.98	30
No	95.02	573
Total	100.00	603
1.2. Environmental sciencies	%	Obs.
Yes	2.16	13
No	97.84	590
Total	100.00	603
1.2. Biosciences	%	Obs.
Yes	4.64	28
No	95.36	575
Total	100.00	603
1.2. Machinery,process,automation	%	Obs.
Yes	2.32	14
No	97.68	589
Total	100.00	603
1.2. Energy tech.	%	Obs.
No	100.00	603
1.2. Electrical tech.	%	Obs.
Yes	7.96	48
No	92.04	555
Total	100.00	603
1.2. Technical physics	%	Obs.
Yes	11.28	68
No	88.72	535
Total	100.00	603
1.2. Information tech.	%	Obs.
Yes	0.17	1
No	99.83	602
Total	100.00	603
1.2. Chemical eng.	%	Obs.
Yes	7.13	43
No	92.87	560
Total	100.00	603
1.2. Environmental tech.	%	Obs.
Yes	0.33	2
No	99.67	601
Total	100.00	603

1.2. Paper tech.	%	Obs.
Yes	1.49	9
No	98.51	594
Total	100.00	603

1.2. Material tech.	%	Obs.
Yes	4.64	28
No	95.36	575
Total	100.00	603

1.2. Industrial econ.	%	Obs.
No	100.00	603

1.2. Medical sciences	%	Obs.
Yes	9.12	55
No	90.88	548
Total	100.00	603

1.2. Economics	%	Obs.
Yes	0.83	5
No	99.17	598
Total	100.00	603

1.2. Law	%	Obs.
Yes	0.17	1
No	99.83	602
Total	100.00	603

1.2. Other	%	Obs.
Yes	2.99	18
No	97.01	585
Total	100.00	603

1.3. Primarily studied in Finland	%	Obs.
Yes	93.99	563
No	6.01	36
Total	100.00	599

1.4. Visited any other country for at least half a year during studies

	%	Obs.
Yes	33.73	199
No	66.27	391
Total	100.00	590

	Mean	S.D.	Min	Max	Obs.
1.5. Year of highest degree	1993	10.03	1961	2007	598

	Mean	S.D.	Min	Max	Obs.
1.6. Birth year	1962	10.82	1936	1980	596

1.7. Number of scientific publications	%	Obs.
None	3.85	23
1-9	20.23	121
10-19	17.73	106
20-49	24.25	145
50-100	14.55	87
>100	19.40	116
Total	100.00	598

1.8. Number of patent applications	%	Obs.
None	45.84	270
1-5	37.18	219
6-10	7.13	42
11-20	5.60	33
>20	4.24	25
Total	100.00	589

1.9. Which of the following organisations have you worked?

1.9. Finnish universities or research institutes

	%	Obs.
Yes	97.75	564
No	2.25	13
Total	100.00	577

1.9. Foreign universities or research institutes

	%	Obs.
Yes	61.19	227
No	38.81	144
Total	100.00	371

1.9. Small firms in Finland	%	Obs.
Yes	35.64	98
No	64.36	177
Total	100.00	275

1.9. Large firms in Finland	%	Obs.
Yes	43.87	136
No	56.13	174
Total	100.00	310

1.9. Firms abroad	%	Obs.
Yes	12.79	28
No	87.21	191
Total	100.00	219

1.10. Present employer type	%	Obs.
University	63.42	378
Research insitute	17.95	107
Firm	14.60	87
Other	4.03	24
Total	100.00	596

2.1. Size of research team	%	Obs.
1-4	15.32	78
5-10	37.13	189
11-20	30.65	156
21-100	14.54	74
>100	0.79	4
Do not know	1.57	8
Total	100.00	509

2.2. Research group conducts inter-disciplinary research

	%	Obs.
Yes	78.39	399
No	17.09	87
Do not know	4.52	23
Total	100.00	509

2.3. Importance of the following sources of funding for the research group during the last five years:

2.3. Own funding	%	Obs.
Not important	14.17	68
Slighly important	26.46	127
Important	22.08	106
Highly important	29.79	143
Do not know	7.50	36
Total	100.00	480

2.3. Academy of Finland	%	Obs.
Not important	17.68	84
Slighly important	15.16	72
Important	21.47	102
Highly important	42.11	200
Do not know	3.58	17
Total	100.00	475

2.3. Tekes	%	Obs.
Not important	21.24	99
Slighly important	12.45	58
Important	17.81	83
Highly important	43.13	201
Do not know	5.36	25
Total	100.00	466

2.3. Foundations in Finland	%	Obs.
Not important	27.06	125
Slighly important	31.82	147
Important	22.29	103
Highly important	13.42	62
Do not know	5.41	25
Total	100.00	462

2.3. EU	%	Obs.
Not important	26.54	121
Slighly important	24.78	113
Important	21.49	98
Highly important	21.27	97
Do not know	5.92	27
Total	100.00	456

2.3. Other foreign public sources	%	Obs.
Not important	56.87	236
Slighly important	18.07	75
Important	6.99	29
Highly important	6.51	27
Do not know	11.57	48
Total	100.00	415

2.3. Firm funding	%	Obs.
Not important	30.24	140
Slighly important	22.46	104
Important	17.71	82
Highly important	22.25	103
Do not know	7.34	34
Total	100.00	463

2.4. Share of firm funding	%	Obs.
0%	29.67	151
1-25%	43.03	219
26-50%	15.13	77
>50%	3.73	19
Do not know	8.45	43
Total	100.00	509

2.5. Change in share of firm funding	%	Obs.
Decreased	14.20	71
Unchanged	45.00	225
Increased	23.60	118
Do not know	17.20	86
Total	100.00	500

3.1 Have you been engaged with firms in any of the following ways during the last five years?

3.1. Conferences or seminars	%	Obs.
Not at all	14.65	74
Slightly	35.45	179
Quite much	33.27	168
Very much	15.84	80
Do not know	0.79	4
Total	100.00	505

3.1. Lectures tailored for firms	%	Obs.
Not at all	62.42	309
Slightly	24.65	122
Quite much	9.49	47
Very much	2.83	14
Do not know	0.61	3
Total	100.00	495

3.1. Supervision of thesis	%	Obs.
Not at all	65.06	324
Slightly	21.69	108
Quite much	8.43	42
Very much	4.02	20
Do not know	0.80	4
Total	100.00	498

3.1. Joint publications	%	Obs.
Not at all	51.20	256
Slightly	30.00	150
Quite much	14.80	74
Very much	3.20	16
Do not know	0.80	4
Total	100.00	500

3.1. Consult firms' R&D	%	Obs.
Not at all	39.31	195
Slightly	32.06	159
Quite much	22.78	113
Very much	5.24	26
Do not know	0.60	3
Total	100.00	496

3.1. Public R&D-progs. with firms	%	Obs.
Not at all	26.06	129
Slightly	22.02	109
Quite much	21.41	106
Very much	29.49	146
Do not know	1.01	5
Total	100.00	495

3.1. Bilateral R&D funded by firms	%	Obs.
Not at all	47.08	234
Slightly	21.13	105
Quite much	19.32	96
Very much	11.27	56
Do not know	1.21	6
Total	100.00	497

3.1. Joint research or other facilities

	%	Obs.
Not at all	74.13	364
Slightly	18.94	93
Quite much	4.89	24
Very much	1.02	5
Do not know	1.02	5
Total	100.00	491

3.1. Working at firms	%	Obs.
Not at all	86.09	421
Slightly	7.16	35
Quite much	2.66	13
Very much	3.07	15
Do not know	1.02	5
Total	100.00	489

3.1. In some other way	%	Obs.
Not at all	71.31	169
Slightly	2.53	6
Quite much	3.38	8
Very much	2.95	7
Do not know	19.83	47
Total	100.00	237

3.2. Transfers research information to firms

	%	Obs.
Not at all	24.12	123
Slightly	34.90	178
Quite much	30.78	157
Very much	9.41	48
Do not know	0.78	4
Total	100.00	510

3.3. Mode of firm contacts made	%	Obs.
Own contact	26.09	132
Research group	30.24	153
Firm	29.84	151
No firm contacts	13.83	70
Total	100.00	506

3.4. Intermediating organisations have been important for faciliating firm contacts

	%	Obs.
Yes	15.14	76
No	68.73	345
Do not know	16.14	81
Total	100.00	502

3.5. If you are engaged with firms in your research activities, how often have you achieved the following things?

3.5. Received funding	%	Obs.
Never	22.07	98
Sometimes	31.76	141
Quite often	28.83	128
Very often	13.29	59
Do not know	4.05	18
Total	100.00	444

3.5. Identification of research questions

	%	Obs.
Never	20.68	91
Sometimes	32.50	143
Quite often	33.86	149
Very often	9.77	43
Do not know	3.18	14
Total	100.00	440

3.5. Identification of commercial opportunities

	%	Obs.
Never	32.43	143
Sometimes	34.69	153
Quite often	24.94	110
Very often	4.31	19
Do not know	3.63	16
Total	100.00	441

3.5. Patenting	%	Obs.
Never	50.91	224
Sometimes	29.09	128
Quite often	13.41	59
Very often	2.95	13
Do not know	3.64	16
Total	100.00	440

3.5. Commercial licensing	%	Obs.
Never	70.51	306
Sometimes	19.12	83
Quite often	5.99	26
Do not know	4.38	19
Total	100.00	434

3.5. Something else	%	Obs.
Never	63.46	99
Sometimes	1.92	3
Quite often	3.21	5
Very often	3.85	6
Do not know	27.56	43
Total	100.00	156

3.6 To what degree do the following things make it more difficult to disseminate research results to firms?

3.6. Passive researchers	%	Obs.
Not at all	62.99	308
Slightly	19.63	96
Quite much	6.54	32
Very much	2.25	11
Do not know	8.59	42
Total	100.00	489

3.6. Basic research orientation	%	Obs.
Not at all	20.00	100
Slightly	28.00	140
Quite much	20.80	104
Very much	26.80	134
Do not know	4.40	22
Total	100.00	500

3.6. Challenges of commercial applications

	%	Obs.
Not at all	18.31	89
Slightly	31.69	154
Quite much	30.66	149
Very much	10.70	52
Do not know	8.64	42
Total	100.00	486

3.6. Communication problems	%	Obs.
Not at all	37.58	183
Slightly	38.81	189
Quite much	11.50	56
Very much	3.49	17
Do not know	8.62	42
Total	100.00	487

3.6. Ownership issues	%	Obs.
Not at all	38.40	187
Slightly	34.70	169
Quite much	12.53	61
Very much	4.31	21
Do not know	10.06	49
Total	100.00	487

3.6. Insufficient knowledge of business

	%	Obs.
Not at all	19.34	94
Slightly	35.39	172
Quite much	25.72	125
Very much	8.44	41
Do not know	11.11	54
Total	100.00	486

3.6. Lack of production technologies

	%	Obs.
Not at all	26.39	128
Slightly	32.78	159
Quite much	18.56	90
Very much	5.77	28
Do not know	16.49	80
Total	100.00	485

3.6. Firms’ lack of interest	%	Obs.
Not at all	18.97	92
Slightly	29.48	143
Quite much	28.87	140
Very much	13.40	65
Do not know	9.28	45
Total	100.00	485

3.6. Something else	%	Obs.
Not at all	54.25	83
Slightly	0.65	1
Quite much	6.54	10
Very much	4.58	7
Do not know	33.99	52
Total	100.00	153

3.7. Interested in founding a firm based on research

	%	Obs.
Yes	19.84	101
No	55.21	281
Already founded firm	9.04	46
Do not know	15.91	81
Total	100.00	509

3.8. Size of co-operating firms	%	Obs.
Small firms	30.95	156
Large firms	47.82	241
No contacts	16.07	81
Do not know	5.16	26
Total	100.00	504

3.9. Country of co-operating firms	%	Obs.
Finnish firms in Finland	76.18	323
Foreign firms in Finland	8.49	36
Firms abroad	12.03	51
Do not know	3.30	14
Total	100.00	424

4.1 Have you been engaged with universities or research institutes in any of the following ways during the last five years?

4.1. Conferences or seminars	%	Obs.
Not at all	2.35	2
Slightly	31.76	27
Quite much	40.00	34
Very much	24.71	21
Do not know	1.18	1
Total	100.00	85

4.1. Supervision of thesis	%	Obs.
Not at all	32.56	28
Slightly	38.37	33
Quite much	17.44	15
Very much	10.47	9
Do not know	1.16	1
Total	100.00	86

4.1. Joint publications	%	Obs.
Not at all	36.05	31
Slightly	29.07	25
Quite much	13.95	12
Very much	19.77	17
Do not know	1.16	1
Total	100.00	86

4.1. Consult R&D	%	Obs.
Not at all	15.12	13
Slightly	29.07	25
Quite much	29.07	25
Very much	25.58	22
Do not know	1.16	1
Total	100.00	86

4.1. Public R&D-programs	%	Obs.
Not at all	16.09	14
Slightly	26.44	23
Quite much	32.18	28
Very much	24.14	21
Do not know	1.15	1
Total	100.00	87

4.1. Bilateral R&D projects	%	Obs.
Not at all	11.49	10
Slightly	21.84	19
Quite much	22.99	20
Very much	42.53	37
Do not know	1.15	1
Total	100.00	87

4.1. Joint R&D or other facilities	%	Obs.
Not at all	37.65	32
Slightly	32.94	28
Quite much	15.29	13
Very much	11.76	10
Do not know	2.35	2
Total	100.00	85

4.1. Working at university	%	Obs.
Not at all	58.82	50
Slightly	20.00	17
Quite much	4.71	4
Very much	15.29	13
Do not know	1.18	1
Total	100.00	85

4.1. In some other way	%	Obs.
Not at all	52.17	12
Slightly	8.70	2
Quite much	8.70	2
Very much	17.39	4
Do not know	13.04	3
Total	100.00	23

4.2. Receives relevant information from universities or research institutes

	%	Obs.
Not at all	1.15	1
Slightly	34.48	30
Quite much	41.38	36
Very much	19.54	17
Do not know	3.45	3
Total	100.00	87

4.3. Mode of university contacts made	%	Obs.
Own contact	41.38	36
Firm	35.63	31
University	22.99	20
Total	100.00	87

4.4 When in contact with universities or research institutes in your R&D activities, how often have you achieved the following things?

4.4. Identification of new product ideas

	%	Obs.
Never	29.89	26
Sometimes	47.13	41
Quite often	17.24	15
Very often	4.60	4
Do not know	1.15	1
Total	100.00	87

4.4. Patenting	%	Obs.
Never	43.68	38
Sometimes	35.63	31
Quite often	16.09	14
Very often	2.30	2
Do not know	2.30	2
Total	100.00	87

4.4. Commercial licensing	%	Obs.
Never	71.26	62
Sometimes	14.94	13
Quite often	10.34	9
Very often	1.15	1
Do not know	2.30	2
Total	100.00	87

4.4. Recruitment	%	Obs.
Never	14.94	13
Sometimes	47.13	41
Quite often	25.29	22
Very often	10.34	9
Do not know	2.30	2
Total	100.00	87

4.4. Development of existing products

	%	Obs.
Never	20.69	18
Sometimes	39.08	34
Quite often	29.89	26
Very often	9.20	8
Do not know	1.15	1
Total	100.00	87

4.4. Development of new products	%	Obs.
Never	25.29	22
Sometimes	39.08	34
Quite often	31.03	27
Very often	3.45	3
Do not know	1.15	1
Total	100.00	87

4.4. Something else	%	Obs.
Never	64.29	9
Sometimes	7.14	1
Quite often	14.29	2
Very often	7.14	1
Do not know	7.14	1
Total	100.00	14

4.5 To what degree do the following things make it more difficult to receive research results from universities or research institutes?

4.5. Passive researchers	%	Obs.
Not at all	22.09	19
Slightly	38.37	33
Quite much	19.77	17
Very much	4.65	4
Do not know	15.12	13
Total	100.00	86

4.5. Basic research orientation	%	Obs.
Not at all	16.28	14
Slightly	33.72	29
Quite much	34.88	30
Very much	8.14	7
Do not know	6.98	6
Total	100.00	86

4.5. Challenges of commercial applications

	%	Obs.
Not at all	11.63	10
Slightly	22.09	19
Quite much	38.37	33
Very much	18.60	16
Do not know	9.30	8
Total	100.00	86

4.5. Communication problems	%	Obs.
Not at all	30.23	26
Slightly	38.37	33
Quite much	22.09	19
Very much	3.49	3
Do not know	5.81	5
Total	100.00	86

4.5. Ownership issues	%	Obs.
Not at all	25.58	22
Slightly	32.56	28
Quite much	20.93	18
Very much	13.95	12
Do not know	6.98	6
Total	100.00	86

4.5. Researchers’ insuff. buss. skills	%	Obs.
Not at all	13.95	12
Slightly	31.40	27
Quite much	33.72	29
Very much	12.79	11
Do not know	8.14	7
Total	100.00	86

4.5. Lack production technologies	%	Obs.
Not at all	12.79	11
Slightly	31.40	27
Quite much	37.21	32
Very much	8.14	7
Do not know	10.47	9
Total	100.00	86

4.5. Something else	%	Obs.
Not at all	57.14	12
Quite much	14.29	3
Very much	14.29	3
Do not know	14.29	3
Total	100.00	21

4.6. Nationality of co-operating universities

	%	Obs.
Finnish universities	82.76	72
Foreign universities	16.09	14
Do not know	1.15	1
Total	100.00	87

4.7. Types of co-operating research institutes

	%	Obs.
VTT	45.98	40
Other domestic research institut	31.03	27
Research institutes abroad	17.24	15
Do not know	5.75	5
Total	100.00	87

4.8. Degree of collaboration with other firms

	%	Obs.
Not at all	4.60	4
Slightly	33.33	29
Quite much	42.53	37
Very much	18.39	16
Do not know	1.15	1
Total	100.00	87

5.1. How well do the following atom- or molecular-level approaches describe the content of your present research or development activities?

5.1. Measurement scale < 100 nm	%	Obs.
Not at all	20.82	122
Slightly	15.36	90
Quite much	18.77	110
Very much	42.66	250
Do not know	2.39	14
Total	100.00	586

5.1. Modelling of new materials, etc.	%	Obs.
Not at all	23.25	136
Slightly	14.36	84
Quite much	17.78	104
Very much	42.56	249
Do not know	2.05	12
Total	100.00	585

5.1. Manipulation of new structures	%	Obs.
Not at all	16.30	96
Slightly	19.19	113
Quite much	29.37	173
Very much	32.26	190
Do not know	2.89	17
Total	100.00	589

5.1. Use of new techs for materials with new funcs.

	%	Obs.
Not at all	22.87	134
Slightly	24.57	144
Quite much	26.11	153
Very much	24.06	141
Do not know	2.39	14
Total	100.00	586

5.1. Production of new materials, etc.	%	Obs.
Not at all	35.84	210
Slightly	17.58	103
Quite much	13.99	82
Very much	30.72	180
Do not know	1.88	11
Total	100.00	586

5.2. Nano definition describes the content of respondent’s work

	%	Obs.
Not at all	23.53	140
Slightly	22.69	135
Quite much	23.19	138
Very much	28.40	169
Do not know	2.18	13
Total	100.00	595

5.4. Applied funding from Academy of Finland or FinNano

	%	Obs.
Yes	47.39	282
No	46.72	278
Do not know	5.88	35
Total	100.00	595

5.5. Initiation of current research	%	Obs.
<2 years	6.57	39
2-4 years	19.87	118
5-10 years	34.01	202
11-20 years	24.58	146
>20 years	13.13	78
Do not know	1.85	11
Total	100.00	594

5.6. How important have the following drivers been for initiating research in your present primary research or development field

5.6. Own research int.	%	Obs.
Not important	2.03	12
Slighly important	5.41	32
Important	19.46	115
Highly important	71.91	425
Do not know	1.18	7
Total	100.00	591

5.6. Research int. of supervisor	%	Obs.
Not important	23.59	138
Slighly important	20.17	118
Important	32.14	188
Highly important	20.85	122
Do not know	3.25	19
Total	100.00	585

5.6. Public funding	%	Obs.
Not important	13.44	79
Slighly important	29.93	176
Important	36.05	212
Highly important	18.37	108
Do not know	2.21	13
Total	100.00	588

5.6. New research instruments	%	Obs.
Not important	21.05	124
Slighly important	30.39	179
Important	31.24	184
Highly important	15.62	92
Do not know	1.70	10
Total	100.00	589

5.6. Going abroad	%	Obs.
Not important	30.49	179
Slighly important	31.69	186
Important	25.72	151
Highly important	10.22	60
Do not know	1.87	11
Total	100.00	587

5.6. Needs of firms	%	Obs.
Not important	31.18	183
Slighly important	25.04	147
Important	23.17	136
Highly important	18.57	109
Do not know	2.04	12
Total	100.00	587

5.6. Commercialisation potential	%	Obs.
Not important	32.20	189
Slighly important	24.87	146
Important	24.19	142
Highly important	16.35	96
Do not know	2.39	14
Total	100.00	587

5.6. Something else	%	Obs.
Not important	46.71	78
Important	5.39	9
Highly important	14.37	24
Do not know	33.53	56
Total	100.00	167

6.1. Choose at the most three industries that hold the most potential for applications of your research or development activities

6.1. Electronics	%	Obs.
No	49.42	298
Yes	50.58	305
Total	100.00	603

6.1. Metals and engineering	%	Obs.
No	78.28	472
Yes	21.72	131
Total	100.00	603

6.1. Foodstuffs	%	Obs.
No	80.10	483
Yes	19.90	120
Total	100.00	603

6.1. Textiles and clothing	%	Obs.
No	95.85	578
Yes	4.15	25
Total	100.00	603

6.1. Wood and paper	%	Obs.
No	79.77	481
Yes	20.23	122
Total	100.00	603

6.1. Pharmaceuticals	%	Obs.
No	56.55	341
Yes	43.45	262
Total	100.00	603

6.1. Other chemicals	%	Obs.
No	71.48	431
Yes	28.52	172
Total	100.00	603

6.1. Energy	%	Obs.
No	83.25	502
Yes	16.75	101
Total	100.00	603

6.1. Other manufacturing	%	Obs.
No	93.20	562
Yes	6.80	41
Total	100.00	603

6.1. Construction	%	Obs.
No	96.68	583
Yes	3.32	20
Total	100.00	603

6.1. Retail sale and services	%	Obs.
No	95.36	575
Yes	4.64	28
Total	100.00	603

6.2. Timing of international market penetration

	%	Obs.
Already	39.20	234
<5 years	20.94	125
5-10 years	15.58	93
>10 years	4.19	25
Do not know	20.10	120
Total	100.00	597

6.3. Timing of first commercial applications

	%	Obs.
Already	25.34	151
<5 years	24.16	144
5-10 years	17.11	102
>10 years	6.21	37
Do not know	27.18	162
Total	100.00	596

6.4. Which is your standpoint regarding the following claims concerning the development of your research field in Finland

6.4. There is a need for new interdisc. post-graduate education programs

	%	Obs.
Highly disagree	4.89	29
Slightly disagree	21.25	126
Slightly agree	35.92	213
Highly agree	34.91	207
Do not know	3.04	18
Total	100.00	593

6.4. Researchers do not have knowledge about the IPR issues

	%	Obs.
Highly disagree	10.47	62
Slightly disagree	33.45	198
Slightly agree	36.49	216
Highly agree	11.49	68
Do not know	8.11	48
Total	100.00	592

6.4. Researchers participate actively in international networks

	%	Obs.
Highly disagree	1.52	9
Slightly disagree	18.69	111
Slightly agree	43.10	256
Highly agree	35.19	209
Do not know	1.52	9
Total	100.00	594

6.4. Public funding is directed to the correct research fields

	%	Obs.
Highly disagree	9.56	57
Slightly disagree	39.60	236
Slightly agree	34.56	206
Highly agree	8.89	53
Do not know	7.38	44
Total	100.00	596

6.4. The lack of standards is a bottleneck for developments

	%	Obs.
Highly disagree	43.07	255
Slightly disagree	31.25	185
Slightly agree	9.12	54
Highly agree	0.84	5
Do not know	15.71	93
Total	100.00	592

6.4. The commercial interest of large firms is declining

	%	Obs.
Highly disagree	18.07	107
Slightly disagree	32.94	195
Slightly agree	18.92	112
Highly agree	6.08	36
Do not know	23.99	142
Total	100.00	592

6.4. The expectations of financiers regard. comm. times are realistic

	%	Obs.
Highly disagree	18.10	107
Slightly disagree	39.76	235
Slightly agree	16.75	99
Highly agree	2.20	13
Do not know	23.18	137
Total	100.00	591

6.4. The university is better at commerc. research than researchers

	%	Obs.
Highly disagree	24.07	142
Slightly disagree	27.63	163
Slightly agree	13.90	82
Highly agree	3.73	22
Do not know	30.68	181
Total	100.00	590

APPENDIX 3. GEOGRAPHICAL DISTRIBUTION OF ALL RESPONDENTS.

Municipality	**N**	**%**
Espoo	145	24,6
Helsinki	136	23,1
Turku	84	14,2
Tampere	55	9,3
Abroad	34	5,8
Oulu	29	4,9
Jyväskylä	27	4,6
Kuopio	18	3,1
Vantaa	12	2,0
Joensuu	11	1,9
Kirkkonummi	5	0,8
Lappeenranta	5	0,8
Lahti	4	0,7
Lammi	4	0,7
Pori	3	0,5
Salo	3	0,5
Kokkola	2	0,3
Pietarsaari	2	0,3
Other	11	1,9
Total	**590**	100

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