Final Activity Report

The Vanish Box:
Disappearance of Women in Science; Reappearance in Technology Transfer

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Summary

The technology transfer professions require hybrid competence: one has to understand research logic, to have experience and understanding of the business world, to understand research and development funding mechanisms and have basic knowledge about policy making. The loss of women at upper levels of academic science is complemented by their reappearance in emerging professions concerned with the economic and social uses of science. We call this disappearance and reappearance "the Vanish Box" and identify four phases in its operation:

1. Blockages to rise in an old professional area;
2. Disappearance into a "reserve army" available for potential recall;
3. Creation of new professional field requiring skills of the old profession; and
4. Reappearance of previously excluded persons in the new profession.

In this report, we examine some of the hidden mechanisms of the Vanish Box and attempt to explain how they work. Also we give a short overview on the state of the new profession

I. Introduction

We are all familiar with the old Vanish box magic trick. A person goes into a closet-like cabinet. The door closes. A magician intones. The door reopens. No one is there. The door closes and, with the wave of a wand, reopens and the person reappears. The audience doesn't know where they were in the interim. A significant number of highly qualified women in science apparently disappear from the scientific career pipeline as if into a Vanish Box. Highly motivated women, who are unable to use their training in traditional academic fields, are available to pursue alternative career paths. Blocked from pursuing high-level careers in academic science, these apparent dropouts are more appropriately characterized as "Push-outs." Some become full time homemakers or pursue careers unrelated to science. Others re-tool and reappear in technology transfer and other science-related interface professions.

A Vanish Box, rather than a pipeline, may be the most appropriate metaphor for the situation of women in science. The classic pipeline metaphor suggests a steady flow through the system: increase the numbers entering a field in secondary school and university and in a predictable time they should appear at the upper reaches of the academic career ladder in relative proportion to their initial entry (Zuckerman, Cole and Bruer, 1991). However, only a relatively few women attain high-level university positions even though increasing numbers of women are trained in scientific disciplines. For example, in Germany only about 11% of professors are female (Statistisches Bundesamt 2008). The blockages that impede women from rising in proportion to their numbers have created a "reserve army" of PhD's seeking an outlet for their talents (Etzkowitz, Kemelgor and Uzzi, 2000). What happens to these women in science who have made a considerable personal investment, matched by society's investment, in their human capital development?

The European Union's concern about failure to fully utilize society's investment in highly trained human resources was the basis for the WIST research project sponsored by the Science and Society program in Framework 6. We wish to better understand the changing relationship among gender, science and the economy through the study of women's participation and advancement in the Technology Transfer, Incubation and Entrepreneurship (TIE) professions in the UK, Germany, Finland and Romania. On the basis of comparative qualitative research on entry into the field, work-life balance, and access to professional networks, we suggest a Vanish Box model to better understand the relative disappearance of women from the upper levels of academic science and their reappearance in TIE at the intersection of science and the economy.

II. Background

The TIE field has grown in importance and expanded in recent years as science has become an increasingly significant pillar of knowledge-based economies, but given its relative novelty, many of its aspects are still largely unexplored. While much of the current debate focuses on the institutional arrangements, efficacy and organizational dynamics of TIE organizations, such as incubators, technology transfer offices, science parks and technology-based start-ups, there has been relatively little analysis of gender relations within TIE organizations (see for example the literature review by Rothaermel et al., 2007). Women attempting entrepreneurial ventures in S&T fields to the economy are often impeded from taking full advantage of their intellectual capital

in negotiating this transition. In a recent study four cohorts of life scientists at a prestige research university in the U.S., Murray and Graham (2007) found that women scientists were excluded from opportunities in commercial science from the very beginning of these activities, leaving them with a lack of self-esteem, professional socialization and skills regarding entrepreneurial activities. Male scientists' interactions with technology transfer organisations were mainly for legal support, administrative and management issues. Women scientists were found to use technology transfer organisations more often than their male peers, in a way described by one woman cited by the authors as "'hand holding' (…) guiding them through an uncertain landscape" (ibid. 671). On the one hand, women scientists may be "ghettoized" into fields presumed to fit with traditional gender roles like educational software. On the other hand, they may lack access to the strong networks that lead to venture capital investment. Indeed, the organization of "Springboard" programmes that give selected women access to venture capital networks is indicative of their previous relative exclusion.

One historical relationship that has been identified between gender and status in science is that women have had a strong presence in newly emerging scientific fields such as drosophila genetics but as the status of the field increases women are displaced by men (Kohler, 1994). Will the early 20th century experience of women largely disappearing from emerging fields such as drosophila genetics, as their status increased, be repeated with respect to TIE in the early 21st century as the stature of TIE professions is enhanced? For example, women were prominent figures in the early leadership of the Association of University Technology Managers (AUTM) but in recent years their presence in leadership roles has declined (Hersey, 2008)

Conversely, as the status of a field declines; it becomes more open to women's participation, for example, veterinary science in Sweden as the country industrialized. Thus, numbers alone are not a sufficient indicator of women's advance in science. The gendered division of labour between economic and social production noted in the 1993 EU Workshop on Women in Science persists to this day (Talapessy, 1994). Men tend to work with men in male dominated occupations and women with women in occupations where women predominate. This sexual separation of labour, a persistent pre-industrial social phenomenon, may even be stronger than the division of labour that was the acknowledged basis of industrial economy. Nevertheless, as new occupations and professions are created in post-industrial society, there is an opportunity to break with previous patterns and set new ones that augur gender equality.

III. Methodology

A "tectonic shift" in the relationship between science and the economy, offering the opportunity to create new technologies and enterprises, is the basis for the emergence of interface professions and new employment opportunities for women in science. What specific organisational processes, institutional and social factors are conducive to this phenomenon and how could they be replicated in the context of other professional areas or institutions for a better representation of women? Can the differences be attributed to particular structural or organisational characteristics or are a consequence of different forms of science? The recent, 18-month research project (October 2006- March 2008) **'Women in Technology Transfer, Incubation and**

Entrepreneurship' funded by the European Commission's DG Research examined these questions, focusing on women's participation and advancement in TIE professions in four countries: UK, Germany, Finland and Romania.

The project team brought together researchers from Newcastle University Business School (UK, project leader), Institute for Employment Research (IAB, Germany), University of Tampere (Finland) and National Centre for Programme Management (Romania). The results of the WIST project were obtained primarily through case studies of five TIE organisations in each of the four countries, selected by type (university and non-university technology transfer offices, science parks, research institutes, semi-public and private business organisation, incubators), maturity of the industry and geographical representation.

Types of institutions selected in each country:

Finland	**Romania**	**United Kingdom**	**Germany**
2 technology transfer offices: one from a university of technology and the other from a multi-faculty university	One university,	three university technology transfer offices	two 'traditional' universities, one technical university, one university of the applied sciences
2 science parks: from bioscience and from engineering fields	One research institute,	one science park	exemplary technology transfer organisations (TTOs) from the German non-university research sector
Innovation intermediaries: a semi-public organisation,	2 technology transfer centres of national research institutes,	an international academic research collaboration.	Network and incubator organisations
a private organisation	One intermediate organisation – its main focus on business (private).		

In each country, 25 semi-structured in-depth expert interviews were conducted with female employees of various hierarchical positions, experience, age, disciplinary background and education. In each organisation, interview guides were used, which covered issues like: work history and science career, current tasks and past experiences in TIE organisations, career opportunities in TIE, importance of networks and networking in the field, gender segregation and work-life-balance issues in TIE from a personal and an institutional perspective. The operation of a Vanish Box became the central focus of this study of women in TIE.

IV. Making a Vanish Box

A Vanish box appears under conditions of significant economic and social change. However, if change is too great, old skills gained in declining industries may be irrelevant to rising industries, creating a surplus labor force. On the other hand, modest change may be accommodated within existing organizational formats. Under intermediate conditions new organizations and roles are created. At the institutional level it involves changes in the rules of the game for relations among societal institutions; at the organizational level it involves creation of a new type of organization. In the topic at hand, the institutions are science and the economy, the organization is the technology transfer unit and the role is the technology transfer professional.

The outcome is the development of an intermediary organization with creation of new roles, formally linking institutional spheres, heretofore unrelated or only informally linked. We initially observed the Vanish Box phenomenon in undertaking studies of women in science in the US (Etzkowitz, Kemelgor and Uzzi, 2000). As part of an investigation of university laboratory alumni, we interviewed women who were no longer pursuing traditional scientific careers. They had become members of emerging professions at the social and economic interfaces of science, having taken up science journalism, science museology, technology transfer and similar careers. Initially appearing as an anomaly, upon further investigation a broad trend was recognised

The supply side of new technologies from well-funded academic research and the need to identify or invent a demand side provides the basis for this new profession (Etzkowitz, 2008). The basic mission of university technology transfer is internal search, external partnering and intellectual property protection. Previous informal channels connecting traditional disciplines and existing industry such as student faculty relationships could not work in scientific fields lacking an industrial base. The creation of new firms required a variety of new organizational formats, ranging from seed venture capital, entrepreneurial training and university technology transfer. The question of how far the role of university technology transfer should extend in assisting the creation of this “eco-system” for high tech firm formation is a continuing issue.

A Vanish Box phenomenon requires invention of a new profession, closely enough related to an old one, that heretofore excluded skilled persons may be recruited into new positions. A Vanish Box has complementary “disappearance” and “reappearance” phases. The first is creation of a “reserve army” of persons available for recruitment into the newly emerging sphere. This may be due to exclusionary practices in an existing structure that leaves significant numbers of trained persons without a position or a shrinking of the old sector leaving large numbers of person unemployed. The second condition is a “tectonic shift in social structures” creating a new organizational format that requires trained persons. The shift must be significant enough to warrant the creation of new organizations, on the one hand, but not too drastic as to make the training for the old position irrelevant to the emerging field. In the following we want to elaborate the mechanisms of the Vanish Box phenomenon on the basis of the WIST project findings.

A. Blockages: Athena Unbound

The first phase of the Vanish Box is the mechanisms that systematically remove significant numbers of women from the academic science career escalator. There has been a gradual increase of women in academic science but the increase is greatest at the lower levels. Indeed, women studying science at the secondary school level and in recent years at the university level their numbers have increased significantly European Commisson, 2006). Currently, half of the undergraduate population of MIT is women. This was not true 10 years ago. It is true today. But only a very small proportion of the senior faculty is women, certainly more than there were 15 years ago. However, the expectation that the so-called "pipeline" would work, that the answer was train more women and that over time, surely within a single academic generation, they would move up from secondary school to university, from bachelors degrees to PhD's and then onwards to RA's and lectureships and upwards to professorships and chairs.

The pipeline sprang a series of leaks. There is evidence of increased flow but it is not as great as it should be given the increase in number of women who have entered the pipeline. The Vice Chancellor of Newcastle University has recently called for an examination of this very issue at his university since women only represent about 18% of the professoriate in 2008, an improvement over 10% in 2003, but still a very modest proportion (Wynarczyk, 2008). The expected flow through the "pipeline" from training through employment and career advancement hasn't happened to as great an extent as was predicted.

In the Athena study we looked for the reasons why this change has not happened automatically simply as a result of training more women and found the answers in the way that the academic system works in a taken for granted fashion. We identified a series of blockages such as the "contradiction between the tenure clock and the biological clock, i.e. frontloading of the academic career coinciding with child-bearing years making it difficult for women to compete; the induction of young men into informal mentoring processes form which women are largely excluded as part of a largely unconscious process of asexual reproduction (Etzkowitz, Kemelgor and Uzzi, 2000).

B. Reserve Army

The Second phase is the creation of a Reserve Army of women in science working at lower levels of the profession than their qualifications or movement outside of the field. In comparing our US data with studies of women in science in other countries we concluded that: Whatever the particular way an academic system is organized; inflexibility in the system virtually always works in a way that excludes women. For example, in the United States, the rule is "exogamy," that is when you finish your PhD you are expected to move to another university. If you want to get the best job, you have to be ready to move anywhere. If a woman has family, a husband with a job, she is typically not as moveable as a man. With notable exceptions, his career will come first and she is not able to move with alacrity. Only in rare cases will a woman place her career ahead of her personal life and go anywhere to take the best job. Thus, the rule of exogamy works against women in the states.

On the other hand in Sweden, the system is just the opposite; it is expected that, if possible, you will stay at your own university to pursue your career and that the best

graduates will be kept at home. Once again, this system also works against women's advance. What if the male partner has to move? The female may or may not be able to move to a good position. However, if she does leave, she will lose the opportunity at the home university that is considered to be the best place to pursue your career if you are to become a leading person in the field. Hence the amazement about the US system expressed by a Swedish colleague, "Why would I let my best student go to another university. He is going to replace me when I retire." Whether it is exogamy or endogamy, any rigid rule impedes women's advancement in science.

The decision not to confront these barriers and refuse to compete for positions at research universities is not unusual. Thus, many highly qualified women find positions in teaching colleges where they try to pursue their research interests in circumstances where significant support is largely lacking. Still others create two/thirds research associate positions for themselves at research universities, competing successfully for grants utilizing a sympathetic faculty member, male or female as a "Beard" in fronting for them to research councils. Yet, others give up the bench completely but remain connected to science. It is this latter group that we are concerned with in the WIST study. We did not attempt to comprehensively cover the universe of "lost" female scientific capital but only the subset that have entered new careers opening up at the interface of science and the economy, especially in technology transfer.

C. Structural, Organizational and Individual Change

The third phase on the construction of a Vanish Box is a change in social structure that requires invention of interface organizations and roles. The confluence of industrial downturn and the rise of new scientific fields with potential for commercial exploitation such as biotechnology created the pre-conditions for the growth of university technology transfer. The closing, but still present, gap between basic and applied knowledge creates the need for translation mechanisms from academic research beyond the traditional one of publication, with take-up left to interested readers or consultation in which incremental advances are passed on to industrial users through personal ties.

Against this background European Technology Transfer organisations arose in part from a perceived need by the European Commission to re-examine its R&D policy, recognising that although Europe possessed (in parts) a strong scientific and technological base, problems existed in both converting knowledge into products and then those products into market shares and profits. Community R&D activities were encouraged to move closer to market, and more effective ways for industry to quickly and effectively exploit R&D results were to be found. These propositions filtered down to the national and regional level and led to a reorganisation of government support for science and technology by focusing on the ways that partnerships and closer co-operation between industry, government and the UK science base could best be established to ensure that the results of research conducted within the science base are translated into commercial products, processes and services (1993 Government White Paper). Similar developments occurred elsewhere.

Nearly all such technology transfer offices (TTOs) we studied had a broader remit than just technology transfer and managed functions such as research contracts, consultancy, and in some cases were also undertaking enterprise teaching and training

activity. TTOs serve as contact offices for technical measurement and testing services as well as technology and (professional) training offered by various university departments. Being another major task, TTOs often engaged in networking and research marketing, for example through public relation trade fairs or technology and knowledge databases made available to the public. Within universities, important tasks include the support of research grant applications, funding activities, and the provision of project services (counseling, administration, management).
One TTO in the UK, the most complex structure which can be found in other countries too, in different ways, but with the same activities, has the following departments:

- Research Development (strategic assistance or supporting bids and large research programmes for the individual facilities in the university; supporting the Research and Knowledge Transfer Committee of the University and in developing the new research strategy in the University),
- Business Development (support for commercialisation or exploitation of intellectual property; intellectual property protection; spin-out company formation activity; practical support to entrepreneurial students/alumni/friends of the university; support for policy development in the knowledge transfer and knowledge exchange area).
- Grants and Contracts (provides support in the pre-award phase of the actual contract- including costing and pricing, negotiation of intellectual property terms, risk management – it is a price optimisation/risk management activity).
- International Development Section (EC research, EC educational programmes and work with international development agencies – Work Health Organisation, World Bank etc)

The professions working in these interface organizations typically require hybrid competence: one has to understand research logic, to have experience and understanding of the business world, to understand research and development funding mechanisms and have the basic knowledge about policy. Technology transfer experts often need knowledge in more than one academic discipline. Either they graduate twofold or they combine an academic degree in one discipline with intense further education in another one.

Academic scientists increasingly recognized that social and networking skills are essential to successful laboratory management. When we think of the economic and social interfaces of science such as incubation and technology transfer, such skills are further fore-fronted. In Brazilian incubators there are often co-directors: a man and a woman. The man handles the external relations, negotiating with government for support, interacting with university officials; the woman mentors the incubator firms. This skewed gendered division of labor suggests that some of the characteristics of traditional female socialization have become a management advantage. Indeed, a female respondent in the TIE study, called men, lacking such skills in highly networked biotechnology firms, “poor lambs.” On the other hand, in traditional areas the technology transfer business is dominated by men, in particular in the technical and engineering fields. Here, not only are professors and faculty often all male but their contacts too, so that in companies interested in technology transfer their partners again are male engineers or heads of development divisions.

It was evident from the interviews that the persons who work in TIE fields perform hybrid roles that often incorporate elements of science and business in their professional design. They have as one of their main tasks to bridge the gap between achievement of R&D results with commercial potential and the creation of new economic activity. In addition as universities become more involved in entrepreneurial activities, the TIE professional's remit may expand from transfer of intellectual property to sensitising faculty, student and staff to the commercial implications of their research, assistance in new business development, participation in regional development organisations and formulating academic policies to promote and regulate third strand activities. A number of job functions are unpacked below.

In order to get a business development effective plan, the following activities have to be achieved:

- Evaluation of technologies for their commercial and economic development potential;
- Participation in the development, marketing and implementation of strategies for the development or commercialization of technologies or other assets;
- Review, develop and negotiate, in association with legal advisors, of legal contracts and other agreements,
- Develop and manage relationships with academic inventors.

An interviewee commented that:

> 'I have a portfolio of technologies that I have responsibility for, not just for promoting but actually getting a commercial outcome and taking them all the way through from concept, right through to prototype development and actually getting some kind of commercial outcome at the end of the day.'

D. Reappearance

The Fourth Phase is recruitment from the "Reserve army" and induction into the new profession. The gender dimension in technology transfer came to the forefront during the rapid expansion of university offices that occurred in the UK in recent years. The expansion was quickly accomplished by hiring underemployed PhD scientists. The trajectories that many of the interviewees had followed to arrive at their current post were varied, such as: dissatisfied with their previous occupations and looking for a change in direction; came across adverts for jobs within TIE organisations; were drawn by many positive aspects of this emerging field. Older and more experienced people have, in the main, been in technology transfer as it evolved (this is the case of UK, with the example:

She has a 1st degree in Biological Sciences and very recently has completed an MBA. She started work as a microbiologist at a leading multinational company. She progressed to become Manager of the Biology Programme. She returned to work full time after having children and felt that although supported at a senior level, she did have problems with the attitude of her colleagues. The organisation split and the business she was working in was subsequently bought out. She was one of the two members of staff from around 60 who were asked to move to Europe. At this point she became disillusioned with the corporate world, precipitated by numerous take-overs and buy-outs and the attendant uncertainty. She returned to the UK and took 6 months out. During this time she worked out which aspects of her work she liked and disliked. [What appealed to her was the application of science in developing businesses. She then moved to an emerging Science Park and began the commercialization of biosciences.] She was then approached to head up the Life Sciences Team with her current employer.

In all countries the persons involved in TIE organisations are well educated, many having PhD's and many short time courses which improved their skills, abilities, knowledge. Qualifications brought with them credibility. The issue of credibility has two facets. Firstly, even those who stated that experience was just as important as formal qualifications acknowledged that a PhD did give those working in technology transfer organisations a level of credibility that was important when dealing with academics. A PhD was significant in earning the respect of academic clients and therefore increasing the likelihood of productive interactions.

> "… because they've got to go in there with some of the top academics in the world and have some credibility".

> "…you don't have to be a specialist in every field but it really helps your credibility in dealing with senior academics if you can appreciate some of the things that they are talking about."

How did employees get into the field and how do they assess their everyday work? There are no clear entry routes**.** Moreover, there are no clear study paths, instead one has to individually construct studies from available courses.
The trajectories that many of the interviewees had followed to arrive at their current post were varied, such as:

- women with a career break – persons who could not continue a traditional scientific career within a setting of university or a research institute.
- Some experts started their career in technology transfer as juniors rather at the beginning of their occupational trajectories.

- Others are already experienced ‘mid-career’ experts when moving into the field.
- Some experts take a chance provided just at the right moment.

> “Yes, at first I was student assistant and then graduated assistant and then it luckily just turned out that a new project was started… and there I could join as an academic professional... and yes, I have been working there until [two years ago]. And then I have taken a leadership position in [title of current project]… I would say it has progressed…”

- Having contacts to an employer in technology transfer and gaining first insights into the occupational field as a student assistant here is important for getting the job.
- Hiring people that are known already personally is the preferred recruitment strategy in this organisation, the expert claims.
- After finishing a doctoral theses one young scientist looked for an alternative to the traditional path of a scientific career in a research setting.

> “I have conferred a doctor’s degree in [field of science]…after having done this I knew that I simply liked to do another job. Tough within science, but not the kind of sitting alone in the laboratory and producing my one results and then perhaps having communication with one more person... but rather [I wanted to simply do things with many different people and with more activities, where you get a result or an output at once. Or a task you work at and finish it within a time frame about one year…] That’s why I wanted to go into this field, into scientific management. I thought just try it, and I liked it from the first day. And that’s why I am there.”

The German team also found a second narrative called ‘job hoppers’ who did not intend to go into technology transfer but they took a chance provided to them.

> “So, it happened more through the backdoor, nothing official with a job post and the like. But I was lucky to be at the right time at the right place.”
> “It was never the case that I was forced to leave… Rather some options have turned out which have been very advantageous for me and then I took them. So I wouldn’t do anything different.”

V. The state of the new profession

There is a trade-off between flexibility, income and career advance in the new profession of technology transfer. In many offices the philosophy was to give people accountability for their jobs and then to give them the freedom and latitude to do the job in the way they saw fit and that delivered the best results. Many respondents commented that their current workplace was one of the most flexible they had ever encountered. An interviewee said that, “During one day, I have different roles and different attitude in different situations. Sometimes I act like a project manager, sometimes I support another project and sometimes I manage inter-organisational projects.” Another mentioned that,”… the absence of pressure to continuously be at the desk was appreciated. “

Nevertheless, this flexibility was not without cost. Salaries in this sector are so low that – as one interviewee put it – “no man would work for” this kind of money] In particular in the public sector, we observed that working in technology transfer – a flourishing field with flat hierarchies, high degrees of freedom and flexibility, and a

positive work atmosphere – comes at the price of few material rewards men are obviously less willing to pay (salaries, opportunities to move up the career ladder).

All interviewees consider networks as significant part of work, but the extent of networks varies by organisational types: In TTOs, it is important to network inside university, with researchers, the secretaries of the departments and administrative officers. It is also important to know and operate with different research funding organisations. If a woman wants to proceed in the field of technology transfer to most important issues and have more power to decide, she has to be aware of the male networks and struggle in order to gain access into them

In contrast to these predominantly male instrumental networks concerned with career advancement were more affective female networks concerned with job survival and those which balance both concerns. Thus, the interviewees told also about many types of female networks:

> The most often mentioned [female networks] were female friend networks rooted in previous working place, education, former colleagues and researcher colleagues. The interviewees thought that these networks help them to survive at work, because difficult situations at work, feelings about working life and balancing work and family life are discussed in them.
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> In our region [of Finland] we have consciously built up sisters' networks, there are two groups. We mirror own work with other's work and own organisation with other's organisation. It is a good thing, it is such tacit knowledge, which is very beneficial…As in old boys' networks, we concentrate in work issues, we do not discuss free-time. Well, maybe we touch it to some point, but the main focus is in work issues. But it is somehow lighter, we bring emotions with us. In one meeting, they are such that one can discharge the feelings and in the other meetings we try to have some theme. One person will introduce the theme and then we will discuss about that. I recommend [these networks], because men have traditionally had more of them and they must consciously be built up.

VI. National variations of the Vanish Box

The conduct of this research in four countries provided the opportunity to examine how the Vanish Box works in innovation systems with significant differences in social structures and gender relations:

a) The **UK case study** suggests that a tentative movement toward gender equality may be identified through the rising importance of relational occupations such as TIE. There is a very strong and widespread perception that gender is not an issue within the TIE sector, which seems to be quite gender neutral: being female or male generates neither advantages nor disadvantages. The sector is populated equally by both sexes, and the gender neutral status of the sector is evidenced in a number of ways. Recruitment and promotion are carried out on the basis of 'the best person for the job'.

Not only are women employed in equal numbers to men, but a high proportion of women are to be found in senior positions, which refutes the existence of a 'glass ceiling' within the sector. While 'old boy networks' proliferate in other sectors, in the TIE sector itself such networks are notably absent. Equally, women's only networks appear to be generic in nature, having a geographic or institutional focus or being targeted at a wide range of 'business women'. Certainly, networks exclusively

populated by women in TIE organisations either do not exist or respondents were completely unaware of them, which suggests that single sex networks have no real value in TIE. The networks that do exist are supported and utilised by those working in the sector and are open and accessible to all.

Some of the main reasons for the seemingly gender-neutral nature of the TIE sector include:

- Flexible working practices, with a high degree of autonomy and freedom in how employees approach their work, producing a family friendly environment that benefits both female and male employees.
- A good work/life balance, even in case of long working hours, which was not done at a cost to family life and was performed as a result of work necessity rather than any culture of 'presenteeism'. The sector was characterised by a 'work hard' culture rather than a 'long hours' culture.
- A general lack of ageism - in fact the opposite is the case, and age and experience is something to be valued. This benefits women in that they are not disadvantaged by taking a career break for family reasons. Although in some instances women reported encountering difficulties when returning to work after maternity leave, these were certainly not at the same level as those experienced in previous work in both academia and industry. Again this perspective benefits both sexes, women taking career breaks and men changing career direction.
- A general perception that work in the TIE sector brings benefits to society and enables TIE employees to interact with other people from a range of organisations, which was often found much more appealing than being 'locked away in a lab somewhere'. Working in TIE was also found as 'fun', highly enjoyable and satisfactory, especially when compared with previous work experiences.

The gender-neutral status of the sector was so advanced that, most often it is a particular type of person that is attracted to work in the TIE sector rather than a particular gender. The movement towards a gender-neutral status within the sector obviously has advantages for both sexes wishing to work in the sector. However, not all aspects of the sector revealed by this research were positive; some negative features were also discerned. In general, the ability of organisations to offer continuous career paths is limited and there were different perceptions on whether the sector was at the stage of maturity to offer a career. This situation is in the main prompted by the relatively small size of organisations and their flat structures.

There is a debate currently ongoing within the sector regarding the necessity of developing formal qualifications specific to the sector. Opinion is divided on whether qualifications or practical experience is more desirable in potential employees, with different organisations placing different emphasis on the necessity of academic qualifications, such as a PhD, as compared to more commercial skills and attributes. In practice, many of those working in the sector have both. People working in the TIE sector cover a wide range of areas of expertise, and recognised that all the necessary knowledge, skills and qualities are unlikely to be found in one person. Therefore, the abilities of the individual are superseded by the overall mix of expertise within the team as a whole and the effective team-working, which appear to be very important throughout the sector.

b) The Finnish case study highlighted different conditions for women's participation in TIE according to institutional type:
1) In technology transfer offices, where work appears to be more stable and regular, but also more rigid and less paid, women employees accounted for about 60 percent. This seemed to be a more accessible environment for women, who occupy many positions in top management.
2) In science parks, where work is more hectic, better paid and involves a lot of networking, women employees appeared to be slightly less represented (about 50 percent) and have less access to top management positions.
3) In private intermediaries, where there are more options for openness, different solutions and alternative thinking, but which are also more stressful, women were the least represented, and their access was rather limited and gained with hard work.

Competencies required for TIE work are complex, ranging from understanding research logic to having experience and understanding of the business world and R&D funding mechanisms. Networking skills were found crucial: a woman succeeds better if she manages to gain access to male networks and build up effective female networks. In generating this experience, the academic degree acts as a basis and is supplemented by various courses on, for example, project management, regional development, product development, commercialisation, patenting, management, EU project management and marketing. Doctoral degrees are seen to be beneficial to working in TIE.

However, in science parks, female employees were often found do lower level work, which does not involve as much developing new ideas and generating new projects. Women instead take responsibility for the practical chores and support the work of males in higher positions. In the organisations studied, men have tasks involving knowledge about the core of technology and networking, whereas women have tasks that require deep knowledge on one area, for example legal rights or funding mechanisms. However, some women have more responsibilities, involving broad development of the field regionally and nationally. Strong male networks appeared to be significant in the TIE field, and women's access to these networks is limited and difficult in all organisational types. Although gender is usually not well articulated in the field of S&T in Finland, women appeared to address gender issues of gender in a natural way and many are aware of the significance of gender in working life.

c) In **Germany,** TIE covers a wide range of activities. The 'classical' transfer of new technology is found particularly at non-university research institutes, centralised and conducted by special technology transfer units, and at universities of applied sciences. Universities and network organisation represent a broader approach to technology transfer, including knowledge transfer via further training and other tasks like research/regional business marketing. All transfer units are embedded into dense network structures co-ordinated through nexus organisations, which provide an interface between different types of organisation from various societal backgrounds, e.g. (academic) spin-offs, business development and entrepreneurship.

The German study suggests that TIE is not a special case of women in science or a field where the usual problems women in science face immediately apply. Most women working in TIE have adjusted their career aspirations to be working close to, but not within science. The perception of a TIE career was closer to a business rather

than a science career. Low pay and a lack of in-house career opportunities were among the most significant shortcomings of working in TIE, although women embraced a wide range of responsibilities. The considerable work flexibility was found positive throughout, but given that almost 50 percent of the women interviewed were working part-time, the intersection of 'career' and 'flexibility' appeared to be a double-edged sword. On the one hand, TIE in its current shape offers women responsible and flexible work and the opportunity to balance career and family but on the other hand, a majority of the women was reluctant to apply the term 'career' to their situation, as their work in TIE was often considered a stop-over before moving into a 'real' career or as the result of career breaks or career-related moves.

From this perspective, TIE careers appear to be the result of an adjustment to events or circumstances that had an impact on women's initial career plans or the career plans of their spouses. Therefore, women unsurprisingly often consider their TIE careers as 'second best' when compared to a career in science, the career of their partners or of people with similar jobs in the private business sector. From this perspective, the TIE field and careers are still in a state of transition. However, women's representation in TIE appeared to be lowest where the profession is most developed or most important, which suggests that, unlike in other countries, for example the U.S., women in German TIE fall back behind their male counterparts at a fast pace, even in occupational fields where they have (re)appeared only recently, once enough rewards and prestige have been accumulated or assigned to attract men.

d) In **Romania,** TIE is still a relatively new area, and the main TIE organisations are grouped in the specialized national network ReNITT, which comprises 34 entities: 12 technology transfer centres, 8 technology information points and 14 technology and business incubators. There are also 7 S&T parks under development. TIE work, just like most other areas in Romania, is usually performed under permanent work contracts for both men and women, and fixed-term and part-time contracts are less usual. Parental leave is possible for both women and men, although it seems to be taken by only a few. Recent evidence found out that in 2005 only 17% of those entitled to parental leave actually took advantage of it, with varying proportions according to the level of education, the highest shares being for the highly educated and the lowest for employees with a low level of education.

The TIE organisations examined in the study have been organised in the last 5 years. In most cases, they are very small (5-10 employees) and are led by males, which is not necessarily the consequence of a gender segregation, but of the fact that more men have a PhD degree in a technical field, and therefore more experience and higher educational background. The TIE experts interviewed appeared to have a wide range of scientific backgrounds. Overall, engineering fields were best represented, followed by management studies and other social sciences, while natural sciences, law and humanities were least represented. The average previous experience in TIE work was of four years, with a minimum of two years for half of the respondents.

Women's presence in top management positions was relatively low, and some interviewees acknowledged that although they had been offered managerial roles, they had refused because of the need for free time. Although some gender asymmetries could be observed in the TIE organisations examined, this cannot be considered to be a result of gender discrimination. Appointment of experts, salaries

and opportunities for career advancement in TIE organisations appeared to be based on competences, experience, performance and professionalism, rather than gender. TIE employees usually have the option of flexible work schemes, working from home or on a project-driven freelance basis, which significantly improves the work-life balance.

The TIE field and careers are by all means still in a state of transition. The conduct of this research in four countries provided the opportunity to examine how the "Vanish Box" works in innovation systems with significant differences in social structures and gender relations. The **UK case study** suggested that a tentative movement toward gender equality may be identified through the rising importance of relational occupations such as TIE. The sector is populated equally by both sexes, and the gender neutral status of the sector is evidenced in a number of ways, including recruitment. The **Finnish case study** highlighted different conditions for women's participation in TIE, in particular regarding institutional type. For example in science parks, female employees were often found do lower level work, which does not involve as much developing new ideas and generating new projects. In **Germany,** women's representation in TIE appeared to be lowest where the profession is most developed or most important. An observation that lends support to the notion that in German TIE, women fall back behind their male counterparts at a fast pace once enough rewards and prestige have been accumulated or assigned to attract men. In **Romania,** TIE is still a relatively new area and women's presence in top management positions was relatively low but overall the appointment of experts, salaries and opportunities for career advancement in TIE organisations appeared to be based on competences, experience, performance and professionalism, rather than gender.

VI. Conclusion: Beyond the Vanish Box

The growth of university technology transfer is based upon the rise of polyvalent knowledge that is both basic and applied, publishable and patentable at one and the same time. Polyvalent knowledge is sometimes referred to as Pasteur's quadrant on the assumption of other quadrants representing basic knowledge, Bohr's quadrant, and wholly applied knowledge, Edison's quadrant (Stokes, 2000). The polyvalence thesis is that a unitary form of knowledge that simultaneously embodies these multiple qualities increasingly supersedes separate quadrants. The opportunity to translate knowledge into use within existing and new organizational frameworks that lack an automatic fit with traditional academic and industrial structures creates the need for interface capabilities.

The loss of women at upper levels of academic science is complemented by their reappearance in emerging professions concerned with the economic and social uses of science. We call this disappearance and reappearance "the Vanish Box" and identify four phases in its operation with the reappearance of previously excluded persons in the new profession at the final stage. Women who have been trained in science, but have not pursued a career in bench science, may be found in emerging careers at the interface of science and the economy. Even if they are no more or have never been engaged in research and development of new technologies itself, these experts have in common that support and manage the "commercial science marketplace" (Murray and Graham 2007: 657). In general, multiple competencies are required for their work in technology transfer, incubation, and entrepreneurship (TIE), including an

understanding of the scientific research background, networking and team working skills. Traditional female gender characteristics heretofore largely relegated to the private sphere are becoming increasingly important in the world of work. For example, relationship management and nurturing characteristics have become more highly valued in occupations emphasizing cooperative and collaborative work within and among organisations. Concomitantly, men may become more like women as they enter relationship management professions. In either case, a convergence toward gender equality, based on universalisation of "female" characteristics may be posited.

A general trend in all countries under study was that, with the exception of people working the legal side of the TIE business, many interviewees had to (re-)invent their own careers since there is no institutionalised 'career' in TIE so far (but an ongoing debate about the need to become more of a profession). Overall, flat hierarchies, flexible working practices, opportunities for a good work-life balance, a lack of ageism, and a general perception that working in TIE is very satisfactory were among the positive characteristics identified by the participants in our case studies. On the negative side – and to a certain extent the other side of the same coin – women in TIE were concerned with a lack of career opportunities (because TIE organisations are limited in their ability to offer continuous career paths) and low salaries (because most TIE organisations are publicly funded, i.e. limited in their ability to offer the salaries paid on the private sector side of commercial science).

As the interface between science, industry and government becomes more central to societal development; it can be expected that the interface professions that link these institutional spheres will rise in status. The position of a field in the S&T universe, its degree of centrality to societal objectives and whether it is on a rising or falling trajectory, affects who is recruited. These qualitative factors should be taken into account in interpreting women's work lives and careers. In some sectors and occupations of the emerging new S&T areas, women remain persistently underrepresented, as in high-tech entrepreneurship, while in others, such as university technology transfer, women seem to be gaining ground.

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