



Meta-analysis of **gender** and **science** research

Synthesis report



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Innovation

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Meta-analysis of gender and science research

Synthesis report

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FOREWORD

Improving working conditions and career prospects for women researchers has been one of my main preoccupations since becoming EU Commissioner for Research, Innovation and Science. It is simply not acceptable that, at a time when we need to harness our creative potential in Europe, we turn a blind eye to the inequities that prevent women researchers from breaking through that “glass ceiling”, or worse still, that lead to women abandoning research careers altogether.



I believe that it is perfectly possible to arrive at a win-win situation where women researchers and the institutions in which they work benefit. The real problem is that we have to overcome the anachronistic mindsets that maintain the status quo for fear of change. But we need to confront out-of-date traditions and practices with hard facts.

This *Meta-analysis of gender and science research* sets out for the first time a comprehensive view of the experience and practices in Europe and abroad amassed over the last thirty years. It shows that women’s advancement in science is too slow. It unravels and exposes the subtle mechanisms that maintain gender inequalities in research institutions, and demonstrates that the traditional view of science as gender-neutral is flawed. On the other hand, and this should come as no surprise, there is also enough evidence that science benefits from the greater involvement of women.

The importance of research and innovation for Europe’s future has been recognised at the highest political levels, and the Innovation Union Initiative launched last year is a cornerstone of the Europe 2020 strategy to stimulate economic growth and create new jobs. Member States are encouraged to reform their research and innovation systems, and a new Innovation Union Scoreboard has been launched to benchmark progress. Let’s seize this opportunity to bring about a restructuring of our research institutions and mainstream gender equality in their practices.

The Commission must lead by example, and so I am absolutely determined that the next EU programme for supporting research and innovation – Horizon 2020 – shall ensure the effective promotion of gender equality and the gender dimension in research and innovation content.

Europe is currently in the midst of an unprecedented economic crisis, but it is not the time to sit waiting for something to happen: we must make something happen! Our strength lies in our potential to develop a world-class economy based on research, knowledge and innovation, but we will need to fully engage the talents of men and women alike.

A handwritten signature in black ink, which reads "Máire Geoghegan-Quinn". The signature is written in a cursive style and is positioned above the printed name.

Máire Geoghegan-Quinn

Table of contents

Executive summary	15
Glossary	26
Introduction	30
Concept and methodology	30
Experts	31
Thematic reports	34
Structure of the report	34
1. Setting the scene	37
1.1 Gender segregation in science	38
Gender segregation in employment	39
Trends of gender segregation in science	44
Gender pay gap	50
Research funding	53
Academic and non academic careers	55
Beyond the leaky pipeline	57
1.2 Research on gender segregation in science	58
Conceptual trends	58
Geographical trends	62
Methodological trends	64
Thematic trends	65
Gaps and key issues	67

2. Scientific careers	71
2.1 Choice of studies	72
Old explanations	72
Structural and life-course factors	73
Socialisation factors	75
Changing stereotypes	78
Reinforcing stereotypes	80
Boys' atypical choices	81
2.2 The 'rush hour' in academia	82
2.2.1 Personal and professional choices	84
Family-or-science dilemma	85
Institutional constraints and departmental cultures	88
Career 'deviations' and leavers	90
Family arrangements	92
2.2.2 Family status and career outcomes	94
Mobility	95
Age and time bars	96
Dedication and availability	98
Scientific productivity	98
2.3 Career advancement in academia	102
2.3.1 Lack of support	106
Mentoring	109
Professional activities and institutional resources	112
Sexual harassment	113
2.3.2 Double standards	117
Formalised peer review processes	120
Cooptation procedures	122
2.4 Scientific careers outside academia	125
Academic versus non academic careers	127

Time and availability	128
Dual professional career system	129
Productivity and mobility criteria	130
Lack of inclusiveness	131
Career breaks	134
The vanish box	135
3. Gender, institutions and knowledge	139
3.1 Institutional change	140
3.1.1 Institutional change in academia	140
New Public Management	140
Departmental cultures	143
3.1.2 New developments outside academia	144
Biotech industry	144
Hybrid professions in science/business interfaces	145
3.1.3 Sociopolitical and institutional change in Eastern countries	147
The gender contract and the scientific career during socialism	148
Post-socialist transformations	149
European integration	150
3.2 Gender analysis in research content	151
3.2.1 Theoretical approaches	153
Gender-neutral approach	153
Difference approach	154
Co-constructionism	154
Gendered innovations	155
3.2.2 Biomedical and health research	157
The concept of sex	158
The concept of gender	159
Intersectionality	160
3.2.3 Engineering and technology	160
Women as designers	161

The co-construction of gender and technology	162
How users matter	162
Rethinking theory: redefining technology	163
Gendered innovations	163
3.3 Policies towards gender equity in science	165
3.3.1 Policy analysis	166
Policy contexts	167
Legislation approaches	169
Policy instruments	172
Policy transfer	174
Policy evaluation	175
3.3.2 Policy research	177
Measures for advancing women's science careers	179
Science management and reform	182
Gender dimension in research and higher education	183
4. Conclusions and recommendations	187
Recommendations	190
Concluding remarks	195
References	197

LIST OF BOXES

Box 1. Promoting excellence through mainstreaming gender equality: ETAN report.	38
Box 2. Trends in gender-employment segregation	39
Box 3. Occupational and sectoral segregation in the highly qualified workforce	42
Box 4. The gender pay gap in research: a comparison of 23 European countries	52
Box 5. Gate-keeping, gender equality and scientific excellence	54
Box 6. Schematic illustration of the diversity of research careers in the European Research Area using Finland as a concrete example	56
Box 7. Leaky pipeline?	57
Box 8. Gender equality in science and technology: Three political approaches	59
Box 9. Research on gender and science: only women, only academia?	61
Box 10. A longitudinal approach to gender segregation	65
Box 11. Exploring cross-national differences in gender gaps in education	74
Box 12. Access of young women to scientific and technical studies	75
Box 13. Media representations of women scientists	77
Box 14. Academic excellence: a family affair?	79
Box 15. Just how male are male nurses...?	81
Box 16. A male career model	84
Box 17. To become a mother is risky for career advancement.	86
Box 18. Researchers between two passions: The example of biologists	93
Box 19. Managing relationships in peripatetic careers: Scientific mobility in the European Union.	95
Box 20. Letter from a woman scientist.	99
Box 21. Only time and mobility constraints?	101
Box 22. Understanding scientific excellence.	104
Box 23. The Matthew effect in science.	105
Box 24. Academic women and hidden discrimination in Finland	108
Box 25. Ambitions without a chance. Gender differences in expectations, ambitions and career efforts of PhD students at the University of Amsterdam.	109
Box 26. Women scientists perceptions of their work conditions and career development ...	112

Box 27. Support, encouragement and recognition in men and women's academic careers. Results from the Athena Survey	114
Box 28. The 'threshold of selection' model: the process of excellence definition	117
Box 29. Professional networks and gender differences in promotion.....	123
Box 30. Working conditions and trends for female researchers in industry in EU Member States	126
Box 31. Gender differences in career entry and career advancement of 'excellent' graduates.....	130
Box 32. Between nepotism and reflexive standards. Personnel policies and career chances in industrial research.....	132
Box 33. Women in engineering research: academic versus industrial research careers	134
Box 34. The vanish box	136
Box 35. The situation of women at Universities in East Germany after the turnaround	149
Box 36. Family and work in the life of Czech women scientists across generations.....	151
Box 37. Granting agencies and current policy approaches for mainstreaming gender analysis in basic and applied research	152
Box 38. Methods of sex and gender analysis.....	156
Box 39. Consequences of the association between masculinity and technology	161
Box 40. History of gender equality.....	170
Box 41. Findings from the meta-analysis of the literature dealing with policies towards gender equity in research	178
Box 42. fFORTE initiative	181

LIST OF FIGURES

Figure 1. Gender occupational segregation in the EU, 1992–2007	39
Figure 1. Proportion of women among highly qualified professionals and researchers (latest available year).....	45
Figure 2. Gender occupational segregation in Europe, 2007	40
Figure 2. Proportions of men and women in a typical academic career (students and academic staff), EU-27, 1999, 2002, 2006	46
Figure 3. Proportion of women and men younger than 60 years appointed as professors in Sweden within 18 years of receiving a PhD among those who took the degree between 1980 and 1985	47

Figure 4. Proportions of men and women in a typical academic career in Finland and Denmark, 1999-2007	47
Figure 5. Proportion of female heads of institutions in the HES, 2007	48
Figure 6. Proportion of women on boards, 2007	49
Figure 7. Schematic presentation of a four-stage research career	55
Figure 8. Average number of publications per year.....	58
Figure 9. Publications by country of publication.....	63
Figure 10. Publications by country analysed.....	63
Figure 11. Percentage of publications by methodological approach	64
Figure 12. Career breaks and working less than full time (LFT) in UK universities, 2006	90

LIST OF TABLES

Table 1. Topics and dimensions	31
Table 2. Experts involved in the study	32
Table 3. Thematic reports.....	34
Table 4. Gender pay gap in % by selected occupations for employees in private enterprises and the public sector, EU-27, 2002 and 2006.....	50
Table 5. Gender pay gap in % by age group for employees in the private and public sectors for the total of occupations 100, 200 and 300, EU-27 and EU-25, 2002 and 2006	51
Table 6. Percentage of publications by technique	64
Table 7. Percentage of publications by thematic issues	66
Table 8. Classification of countries based on <i>European Innovation Scoreboard</i>	168
Table 9. Classification of countries based on <i>The Gender Challenge in Research Funding</i>	168

EXECUTIVE SUMMARY

The purpose of the study Meta-analysis of gender and science research was to collect and analyse research on horizontal and vertical gender segregation in research careers, as well as the underlying causes and effects of these two processes.

The objectives of the study were to:

- Provide an exhaustive overview and analysis of research on gender and science carried out at the European, national, and regional levels.
- Make the study results accessible to researchers and policy-makers via an informed bibliography (online database) and a set of reports.
- Steer policy-making on gender and science and define future research priorities within the Framework Programme, in particular through good practice examples and gap analysis in the various research topics.

For the purposes of the study, 'science' was understood in its broadest meaning, including social sciences and humanities as well as research and technological development.

The study covered the research on gender and science produced between 1980 and 2008, in all European languages, in 33 countries: the 27 EU Member States as well as 6 Associated Countries to the Seventh Framework Programme for Research and Technological Development (FP7) (Croatia, Iceland, Israel, Norway, Switzerland, and Turkey).

The online database (Gender and Science Database, GSD) and the reports are available at the website of the study: www.genderandscience.org

Setting the scene

Gender segregation in employment refers to the tendency of women and men to work in different occupations and sectors. It has long been acknowledged as a pervasive phenomenon in all OECD countries. The literature usually distinguishes between different types of segregation. Horizontal segregation is understood as the under- (over-) representation of a certain group of workers in occupations or sectors not ordered by any criterion, whilst vertical segregation refers to the under- (over) representation of a group of workers in occupations or sectors at the top of a ranking based on 'desirable' attributes –income, prestige, job stability, etc. In the literature, vertical segregation is sometimes referred to as the 'glass ceiling', which points to the existence of visible or invisible obstacles that lead to the scarcity of women in power and decision-making positions. This is completed by the concept of the 'sticky floor', which describes the forces that tend to maintain women at the lowest levels in the organisation.

There is no evidence of any spontaneous movement towards less gender segregation in European countries. On the contrary, the evolution of labour markets over the last 20 years points towards unchanging if not rising levels of segregation, although with significant variation across countries and divergent de-segregation and re-segregation tendencies.

The last decades have witnessed impressive advances of women in education, the enforcement of equality legislation, the progressive loss of importance of physical attributes for productivity, changes in family roles and the challenging of traditional gender norms by feminism. Taking into account these trends, current research focuses on four sets of factors in order

to explain gender segregation: gender stereotypes, choice of study field, gender division of labour and time constraints, and covert barriers and biases in organisational practices. In highly paid professional occupations there is evidence that the influence of the above-mentioned factors of segregation is diminishing, especially among younger cohorts of women. However, women remain more severely underrepresented among researchers than among other highly qualified professionals.

The move towards gender equality in science cannot be taken for granted. Most studies emphasise that gender differences in scientific careers are decreasing for recent cohorts, with women's and men's professional and family trajectories more aligned with each other than ever. This, however, does not mean that women have equal opportunities to attain academic status equal to that of men. Gender inequalities persist in education insofar as the gender ratio differs across fields of study. The existence of a 'glass ceiling' or a 'sticky floor' affects women trying to progress to senior positions. The absence of women in leadership positions tends to be more acute in science and technology occupations than in other fields. Gender segregation may be slowly eroding, but women are still unable to fully develop a scientific career on equal terms with men. Thus, the literature on gender segregation in science shows two main concerns: First, science and the engineering professions seem less responsive to the social forces that are successfully leading to progress towards gender equality in other highly skilled professions (physicians, lawyers...). And secondly, this trend is clearly at odds with the scientific ethos of universalism and meritocracy: if universalism and meritocracy were the actual rules, gender inequality would be less prevalent than in other professions.

Research on gender segregation in science has developed in close relation to political debates and initiatives to foster women's advancement in science. While policy concern has gradually moved from women's recruitment to retention and career advancement, research has shifted from socialisation to organisational approaches, paying special attention to vertical segregation. The initial focus was on gendered socialization –how from an early age individuals internalise 'feminine' and 'masculine' roles that shape their educational and professional choices. The 1990s witnessed a gradual shift in research towards organisations and professions, their implicit norms and standards, institutional practices and power relations. Policy debates during the 2000s have emphasised the need to adopt a comprehensive approach towards gender equality: increasing women's participation in science and engineering will not be successful without restructuring institutions and mainstreaming gender analysis into knowledge production. Recent studies have tended to address the progressive differentiation of men's and women's careers through both supply-side and demand-side factors and have paid increasing attention to overcoming gender biases in knowledge production.

Research on gender and science has developed steadily through the 1990s and 2000s, although a large bulk of the literature is still mainly concerned with women's choices, barriers and deficits and fails to address the societal and institutional factors that are at play. The UK and Germany are the countries with the largest number of publications and both offer a rich strand of empirical research on gender and science issues from an organisational approach. In general, comparative research (across countries, scientific fields and institutional sectors) is scarce and a descriptive approach prevails. Overall, research focuses on

academia and reflects the lack of systematic sex-disaggregated data on scientists and the difficulties involved in collecting professional and personal information.

Gender segregation in scientific careers

A large strand of the literature refers to gender differences in scientific careers, with a focus on three critical moments: choice of studies, which remains largely gendered; the 'rush hour', i.e. the early stage of the scientific career, in which family and career demands most often collide, a fact that disproportionately disadvantages women; and career advancement, which shows persistent gender inequality.

Gender segregation in education is widely acknowledged as one of the roots of gender segregation in science. In spite of desegregation trends over the last decades, study field choices remain largely gendered. Research on gender segregation in education has been extensive although many studies point to two important conceptual problems. First, gender segregation in education is almost always presented from the perspective of the educational choices made by girls, even though gender segregation is also due to boys' preferences for certain fields of study. If the aim is to change these trends and introduce more of a gender balance in all study fields, then it is with respect to the entire set of factors upstream of the study field choices that genuine theoretical and political questioning should take place; while doing so, equal attention should be given to both girls' and boys' choices. Working towards a more mixed composition of all study fields should not mean an alignment to the male model. Second, some strands of the literature are still based on the assumption that the underachievement

of girls compared to boys in maths is the main reason for gender imbalance in university studies. However, differences in maths achievement are narrowing or have disappeared and achievement in maths at school is not a good predictor of choice of study field at university (girls with talent in maths make more diverse choices than equally talented boys). To account for gendered motivations and interests and to gain a better understanding of the educational choices of girls and boys, the main focus of explanatory factors needs to be changed from the analysis of maths performance to gendered socialisation and its interplay with structural and life-course factors. The degree of integration/differentiation in the educational system and the extent of gender equality in society are pointed out as relevant factors.

The review of the literature shows that family and career tensions play an important role in explaining the low rates of women embarking on a scientific career. These tensions are especially acute in the early stages of the academic career, from the first university degree to the first tenure-track position, a long period of career formation with intense productivity and mobility demands that coincides with women's childbearing years and social expectations about the right moment to establish a family. It encompasses the process of obtaining a PhD, carrying out fellowships abroad, being recruited as a post-doc in a scientific institution and competing for a tenure-track or a similar independent research position. Access to a tenure-track position is indeed one of the major critical points. It is a deeply-rooted assumption that future career progression relies very much on performance in this period, a fact that disadvantages women: in addition to biological childbearing, most women continue to bear the primary responsibility for caregiving and household responsibilities. Many studies show that

the family-or-science dilemma is not only gendered, but exacerbated by institutional constraints and implicit academic norms, values and expectations that take the traditional male life-course as the norm. The 'myth' of total availability in the scientific lifestyle penalises involved parents, but also women as potential mothers. Many young women end up believing that science is incompatible with family life and feeling that they have to leave academia if they wish to have a family. And indeed, family related mobility and time constraints may act as a filter in early selection procedures.

The literature also stresses that family and career tensions cannot explain vertical segregation in science. Research shows that the professional and family trajectories of those women who manage to remain in science are more aligned than ever to that of men. Overall, the available empirical studies do not show any clear evidence that women without children have better career prospects than their other female colleagues or that they succeed in catching up with men in their careers. Marriage and children do not appear to have a significant influence on women's scientific productivity and academic performance. To explain gender differences in scientific careers it is necessary to investigate more complex mechanisms, such as discrimination and cumulative advantage and disadvantage. In this way, research goes beyond the universalistic criteria and strict norms that govern the formal procedures of recruitment and promotion in academia, analysing power relations, gate-keeping practices and informal networks as a source of tacit knowledge, support and recognition. Gender discrimination is seen to operate at two distinct, although closely connected, levels. The first is the lack of informal support in career advancement that leads to discouragement. The second refers to bias in formal assessment procedures that

leads to unequal access to research funding or academic positions. The definition and assessment of scientific excellence (the recognition of merit) is not independent of gender relations in academia and society at large. Overall, research concurs that women's poorer networking resources is a powerful, albeit subtle, explanatory mechanism for understanding women's greater attrition and slower career progression compared to men's. It works through an accumulative logic of 'non occurrences' and slight exclusionary practices that progressively disadvantage women's careers and cause a sensation of isolation, difficulty in assuming the risks inherent to the scientific career and low professional self-esteem. Women's slight disadvantages from the early stages of the scientific career might turn into wide differences in career outcomes.

Academia is the dominant concern in the literature on gender and science, with only few studies dealing with industry and other non-academic R&D areas. The overall picture of gender inequality in industrial research, nevertheless, appears to be quite similar to that of academia. Subtle forms of gender discrimination appear to be closely connected to the long hours culture and the lack of flexibility in balancing professional and private lives, shaping a work culture which lacks the atmosphere of inclusiveness. However, research also stresses that human resource management is more developed in industry than in academia and may play an important role in the promotion of an inclusive work culture, with better career support, more transparent recruitment and promotion procedures and a tight focus on recruiting talent and diversity management.

Gender, institutions and knowledge

Another strand of the literature turns to an examination of scientific institutions and

scientific knowledge, with a focus on three different themes: the gender dimension of current institutional changes, gender analysis in research content and policies towards gender equality in science.

Research highlights the ambivalent impact of current institutional changes in both academic and non-academic settings, namely the restructuring of universities under new managerial criteria, the erosion of hierarchy and individual competition in certain research institutions and the development of science and technology-related professions. Ambivalence is also the dominant view in the literature addressing sociopolitical and institutional changes in the former socialist European Eastern countries, in which both gender relations and scientific institutions have experienced important changes.

Recent studies have shown an increase in the number of women leaving academia in order to take up careers in other science- and technology-related professions, which provide not only new career paths, but also more favourable working conditions. In parallel the literature shows an emerging trend towards the erosion of hierarchy and individual competition in certain university departments and R&D firms, which may also favour women's career prospects. A recurrent theme is the drastic change that scientific practice is experiencing and the obsolescence of individualistic reward criteria as science becomes increasingly complex and collective. From this point of view, it is argued that scientists of both sexes (and science itself) would benefit from systems of recruitment, assessment and promotion that took this collective dimension into account. This trend may be seen as consistent with a certain degendering of scientific institutions, driven by the fact that many young women and some young men nowadays appear to want

a more balanced life and are not willing 'to pursue research as the main aim of life'.

However, these wishes collide with increasing competitive pressures in academic institutions and R&D systems. Under current managerial approaches, the move towards greater transparency and accountability in academic assessment procedures is coupled with increasing competition for research funding among institutions and individuals. Whilst the literature in Germany, Austria or Switzerland explores the ways in which these new approaches might serve to foster gender equality in academia, the literature in the UK, where managerialism has been in place longer, focuses rather on its gendered impact on the academic profession. The professionalisation of hiring and selection procedures on the basis of transparent and gender-blind performance criteria can be viewed as a challenge to traditional academic practices of patronage and nepotism. However, mechanical application of quantitative assessment procedures may favour intellectual conformism, exacerbate competition at the individual level and slow down progress towards gender equality, especially against a background of increasing competition for research funding and the intensification of work. Gender-blind performance criteria are not necessarily gender-neutral: bibliometric indicators reflect bias in favour of the past and bias in favour of relational position in the network. Furthermore, the use of such criteria is currently associated with elitist strategies in the allocation of scientific resources, which work against women and minority groups.

The current approach to gender equality in science involves not only supporting women, but reforming scientific institutions and overcoming gender biases in knowledge production. Gender biases in research limit scientific creativity, excellence, and benefit to society. It also hinders women's

advancement in science inasmuch as women are currently the majority of scientists whom acknowledge the relevance of sex and gender analysis. Gender theory has had an enormous impact in the humanities and social sciences over the past thirty years and is increasingly being integrated into medicine and the life sciences, although it remains less well developed in engineering and technology. While in the past research focused on removing gender bias in scientific knowledge, the current research approach employs gender analysis as a resource to enhance scientific excellence. What is needed now is institutional support to translate this approach into methods readily useful to scientists and engineers and to promote their implementation in research policies and scientific institutions.

Research on the evaluation of policies on gender equality in science and research shows a weak impact on institutions and scientific cultures. Measures for advancing women's science careers are highly beneficial for the individual scientist, but institutional constraints and implicit norms and values remain largely unchanged. The same holds true for the persistence of gender bias in research methods, techniques and epistemologies.

Research gaps

Overall, the meta-analysis of the literature provides a clear overview of the most under-researched themes as regards gender and science:

- Non-normative scientific careers is a largely neglected topic. In general, studies concentrate on academia and focus on scientists that pursue the most standard path. Little is known about those scientists who leave the academic pipeline or fail to adjust to the rigidity of academic 'tempo's'.

Industrial research and other science and technology-related professions remain under-researched.

- There is a lack of theoretical and empirical research on the criteria and procedures for assessing scientific excellence. Particularly, studies about research funding are noticeably absent, specifically analysis of the recruitment practices for gate-keeping positions, as well as of the practices of the different bodies and scientific committees that award research grants and funds and assess scientific excellence. Overall, the lack of transparency in awarding procedures hinders empirical research.
- Research on pay in scientific professions is scarce. It is a rather new topic of study, for three reasons: First, there is a lack of available official data on income and gender income differences. Second, in an important number of research institutions wages are entirely determined by rank and seniority. Third, in some countries and in some cultures, discussions of earnings are taboo.
- Research addressing the evaluation of gender equality policies in science and research is scarce. There is a relative abundance of position statements, conceptual clarifications and recommendations dealing with gender issues in science across most countries. There is also a relatively large body of research documenting horizontal and vertical segregation in science. However, there are comparatively fewer systematic evaluations of policy measures.

Recommendations

Women's advancement in science is slow and cannot be taken for granted. While policy action is needed for raising gender awareness and removing institutional constraints and biases, empirical research is required in order to provide a sound basis for policy making.

With the overall purpose of promoting gender equality in science by facilitating non-linear careers and degendering, the main priority of research should be to build more consistent links between analysis and policy making. Recommendations can be grouped into four main issues:

1. Better statistics

R&D and Innovation surveys allow for a clear identification of researchers, but information on qualitative aspects of their employment is very limited.

The European Labour Force Survey is a valuable source of data for the analysis of scientific and technological employment. It offers rich information on personal and family variables. However, it does not make it possible to distinguish clearly between professional and research activities.

European initiatives like the publication of She Figures on a tri-annual basis since 2003 must be applauded. It constitutes a unique attempt and opportunity to build a comparable European database in order to monitor the relative position of women in science. Collecting more systematic sex-disaggregated data on pay and research funding should be a priority. In particular, research funding requires proper monitoring whilst the lack of transparency in the allocation of research grants and awards is a major obstacle.

Major hindrances for research are the lack of sex-disaggregated data on personal and career developments (including demographic variables such as the number of children, marital status, etc.) and the lack of longitudinal data. The systematic collection of personal and career data is of utmost importance for monitoring progress towards both family and career balance and gender equality in scientific

institutions. Overall, further research on family and career tensions is needed, for both men and women, and not only dealing with parenthood but also with other issues, such as care of the elderly. More consistent data is also required to enable an intersectional approach in order to examine how gender and other social inequalities interplay – which is a rather neglected issue. At the same time, research suffers from a lack of panel data, which hinders the development of longitudinal research, which is the best way of analysing patterns of cumulative advantage and disadvantage that shape gender differences in scientific careers. The same holds true for any analysis that aims to take seriously into account the relationship and reciprocal influences of personal and professional lives.

2. Broader scope of research

Overall, research on gender and science should be less descriptive and more theoretically embedded within the strand of literature that analyses divergent patterns of feminisation and change in highly qualified professions.

Only a small percentage of PhD holders (5-20%) pursue an 'excellent' academic career that culminates in a full professorship or similar post and to an even lesser extent enter the restricted circle of the scientific elite. More research is needed to fully understand the complex mix of structural barriers, discrimination and cumulative disadvantages that account for women's underrepresentation in the highest scientific positions. Gate-keeping policies and practices in research funding should also be studied, including the recruitment of gate-keepers, and the impact of gate-keeping positions on gate-keepers' own careers and network building. There is also a need for well-grounded qualitative research on the gender

dimension of the hidden power dynamics that govern access to the elite positions.

However, the underrepresentation of women among the 'excellent' scientists also means that more women than men follow other scientific paths in universities, research institutes, industrial R&D, or other science and technology related professions. Yet research in this field is limited and reinforces gender bias in the analysis of scientific careers. This does not only mean that more attention should be paid to scientists who leave academia, follow discontinued careers or work below potential. Research should also address the development of science-related professions in non-academic settings and its gender dimension, including technicians working as research staff and technology transfer professions.

Finally, research should take fully into account that gender does not mean women and that gender relations are changing. Further research on different femininities and masculinities is needed, particularly in addressing gendered study choices, career and family conflict and scientists' interactions in professional settings.

3. Mainstreaming sex and gender analysis

The global leader in policies to promote mainstreaming sex and gender analysis into basic and applied research is the European Union's DG Research. However, several problems hinder the development of this approach, even in the case of EU funded research. Recommendations for future actions include:

- Developing internationally agreed upon methods of sex and gender analysis. There is a need for gender experts, working with scientists and engineers, to develop internationally agreed upon methods of sex and gender analysis that can serve as a

baseline for understanding how gender functions in research. It is not enough simply to 'add on' a gender component late on in the development of a given project. Research must consider gender from the beginning.

- Training current researchers and evaluators in gender methodology. Designing sex and gender analysis into basic and applied research requires that researchers be trained in specific methods, so that they can address gender issues where appropriate.
- Holding senior management accountable for developing evaluation standards that take into account the proper implementation of gender analysis in research. Granting agencies can require that all applicants include gender methodology in research design; Hiring and promotion committees can evaluate researchers and educators on their success in implementing gender analysis; Editors of peer-reviewed journals can require use of sex and gender methodology when selecting papers for publication.
- Training the next generation in methods of sex and gender analysis. Sex and gender analysis should be taught throughout the curriculum, including basic science, medicine, and engineering curricula, at the primary, secondary, and tertiary levels.

4. Focus on institutional change and evaluation of gender equality policies

'In spite of persistent efforts of data-gathering, research and reflection over the last two decades, increasing knowledge about gender segregation in science has not led to significant improvement'. This is a rather common view among policy-makers and scientists committed to gender equality in science. We contend that we do not know that much whilst some things have indeed changed, although change has not been mainly driven by explicit

institutional intent. Building more consistent links between analysis and policy making should be the main priority for research. This means focusing more consistently on the gender dimension of current institutional developments, including the evaluation of gender equality policies.

Current trends in scientific production and technological development depict a new scenario with increasing links between universities, research institutes and private firms and substantial changes in the structure of scientific careers. Institutional changes may lend support to more inclusiveness in recruitment procedures and working cultures in scientific and research institutions, as documented for certain university departments and R&D firms. However they may also exacerbate individual competition and gender inequality in spite of greater gender awareness in scientific institutions and society at large. Greater attention should be paid to current institutional changes and their impact on gender equality. This entails reinforcing more consistent analysis of institutional change, ranging from in-built monitoring of institutional practices (i.e. scientific evaluation of scientific evaluation) to the development of comparative research, as patterns of exclusion and inclusion vary across national contexts and scientific disciplines and what is effective in a certain context may not be in another. In the field of gender equality policies, primarily implementation strategies are missing and if present are based on unrealistic assumptions about organisations and their potential for change. Evaluation of gender equality policies should be substantially reinforced. This includes:

- The need for common quality standards for evaluation. Evaluations are often linked to the objectives and implementation logic of the project under question and seldom respond to more general evaluation criterion. Whilst the majority of approaches concentrate on the individual level (satisfaction, benefit), a common evaluation framework might be useful for addressing the related problem of detecting structural change. This also points to the need to make the normative component of many evaluation studies explicit.
- The need for theory and interdisciplinarity. Most studies are descriptive and lack explicit theoretical references. The empirical situation under study is seldom distilled and exploited in terms of theoretical concerns or theory building. This reinforces the isolated nature and lack of comparison between case studies across Europe. This makes it hard to compare the insights emerging from the evaluation case studies with other studies and research carried out in OECD countries. Time and time again, disciplinary and institutional differences turn out to be important factors for the successful implementation of certain measures. In order to confront the resulting explosion of empirical details, it is necessary to develop theoretical models that help to see not only the pieces of the puzzle but how they might fit together.
- There is a need for research on long-term effects. The problem of rather isolated studies is further aggravated by the fact that most studies on policy on gender equality in science are also restricted in time. Most evaluations happen just before, during and shortly after the actual activities are carried out without being able to consider their long-term impact. It would be especially important to see not only what works but also why certain measures did not achieve the desired results or might have even been counter-productive. This might be the case for certain examples where the continued emphasis on gender issues has embedded 'equality' on a discursive level but not on a practical one. Transforming practice has to confront not only the ignorance of gender

issues but also a lack of discrimination between the rhetoric of gender equality and real, cultural change.

Concluding remarks

The meta-analysis of the literature on gender and science demonstrates two facts: First, the dimensions of the scarcity of women at all levels of science are well established. A decade of data-gathering, reflection and comparative analysis has demonstrated the reality of horizontal and vertical segregation, the existence of pay gaps, stereotypes, and the biased nature of criteria of excellence. Second, the move towards gender equality is slow and cannot be taken for granted. Women are increasingly underrepresented the higher one climbs up the scientific ladder. The persistence of these inequalities requires a more comprehensive approach to policies for gender equality in science and research in the European Union.

A crucial insight concerns the fact that in order to make progress towards a truly developed knowledge society, science policy targeting the allocation of financial and human resources based on criteria of transparent and fair scientific evaluation procedures will not be sufficient. Rather, in order to take advantage of the existing pool of researchers and innovation talent, a cultural change in terms of challenging traditional gender roles, specifically in terms of more gender-balanced decision making in research, will be required. The scarcity of women in positions of power and science decision making is not a problem that will be resolved over time (as soon as the number of women candidates increase). In fact, the number of women candidates is increasing, but the participation of women in research activities is not associated with more funding for research and innovation or more intense private research efforts. Employers continue to be reluctant to incorporate

women. The key challenge is not to change women but, on the contrary, to change the culture of science and research. This change would concern not only the definition and assessment of excellence but also issues relating to career and family balance.

The strong emphasis placed on work-life balance policies is oriented towards attracting and retaining female talent. The concept of gender diversity is also incorporated as a key element of good management of research and innovation policies. Diversity is required not only for economic reasons (improving efficiency by the optimisation of human resources, gender equity would contribute to competitiveness); diversity also improves the quality of science and research by increasing creativity and bringing science closer to society.

Enhancing scientific excellence also requires overcoming gender biases in knowledge production through the mainstreaming of sex and gender analysis into basic and applied research in the fields of life sciences and technology. This entails addressing sex and gender analysis as a resource to stimulate creativity in science and technology, and by doing so enhance the lives of both men and women. The global leader in this policy approach has been the European Union's DG Research, although further support is needed to promote its implementation in scientific institutions.

Overall, the European Union perspective involves a 'shift from formal equality to equality of opportunity or equality in numbers, to gender balance and equity'.¹ It also involves a different sequence of measures in order to achieve gender goals. At present, the main challenge is not to define

⁽¹⁾ European Commission 2008, *Mapping the Maze. Getting More Women to the Top of Research*, Office for Official Publications of the European Communities, Luxembourg, p. 23.

new policies but to reinforce their effects through an in-depth evaluation of measures and transferability of good practices. It implies developing sound theoretical frameworks, appropriate methodological tools and shared evaluation standards.

In the end, the new European perspective on gender and science comprises the idea that gender policy is not only made by regulation and legal changes but mostly by leadership and a commitment to changing structures and cultures.

GLOSSARY

Sex and gender

'Sex' refers to the biological differences between women and men. 'Gender' is a socio-economic and cultural construct for differentiating roles, responsibilities, constraints, opportunities and needs of women and men in a given context. The unequal power relations between women and men are a central issue for understanding gender relations. While sex is biologically determined, gender is learned and changeable over time, and has wide variations both within and between cultures.

Gender segregation

Gender segregation in employment refers to the tendency of women and men to work in different occupations and sectors. It has long been acknowledged as a pervasive phenomenon in all OECD countries.

The literature usually distinguishes between different types of segregation. Horizontal segregation is understood as the under- (over-) representation of a certain group of workers in occupations or sectors not ordered by any criterion, whilst vertical segregation refers to the under- (over-) representation of a group of workers in occupations or sectors at the top of a ranking based on 'desirable' attributes –income, prestige, job stability, etc (Bettio & Verashchagina, 2009). In the literature, vertical segregation is sometimes referred to as the 'glass ceiling', which points to the existence of visible or invisible obstacles that lead to the scarcity of women in power and decision-making positions. This is completed by the concept of the 'sticky floor', which describes the forces that tend to maintain women at the lowest levels in the organisation.

In the field of science, horizontal segregation refers to the concentration of women and men in certain disciplines or institutional sectors. Vertical segregation concerns the unequal position of women and men within the scientific hierarchy.

Leaky pipeline

Ever since Berryman (1983) introduced the metaphor of the 'leaky pipeline', this conceptual approach has dominated the scientific literature on women in science. According to this perspective, the process of becoming a scientist can be conceptualised as a 'pipeline'. The science pipeline refers to the normative sequence of educational and employment stages that typically comprise a scientific career. From this point of view, the decreasing proportion of women moving up the educational/professional hierarchy is attributable to women's higher rates of attrition from the science pipeline: at each moment of transition from one educational/professional stage to another, the pipeline loses more women than men.

Several authors highlight the need to overcome the shortcomings of the 'leaky pipeline' approach in both research and policy making (Langberg, 2006; Xie & Shauman, 2003). This metaphor bears witness to the fact that women are more severely underrepresented as they climb higher up the career ladder and has significantly enhanced empirical research on gender disparities across the whole process of becoming a scientist. However, it is misleading because it suggests an overly linear approach to the career path that does not take into consideration the many possible interruptions and re-entries. Furthermore, it wrongly suggests that all scientists advance at an equal pace, and that policy should focus on measures to patch up the leaks without considering the institutional constraints and

subtle discrimination which women and other groups may experience in career advancement. Overall, it neither covers the complexity of the educational, professional and vital processes involved in being a scientist, nor those trajectories that move away from the normative linear career in academia.

Scientific excellence

The definition of scientific excellence is elusive. The scientific community acts as if excellence were an obvious quality, and seldom feels the need to define it clearly. According to the documents written by professionals and agencies whose mission is to foster scientific excellence, it can be defined as follows:

Scientific excellence is the ability of a scientist or an institution to impact on a field of study producing a major change, leading other scientists towards asking new questions and producing new, important and useful contributions to knowledge, using new methodologies. The quality of excellence must be proven by a number of means, (such as publications, citations, funding, and students) and recognized by the peers by the bestowing of various honours, prizes and other awards.

The scientific community seems to act as if the meaning of scientific excellence were obvious and agreed on by all participants of the scientific enterprise. It behaves as if scientific excellence were an uncontested terrain and as if the procedures and criteria that lead to the selection of the top layer of scientists who are considered excellent were given, known, and unproblematic. However, contributions in the literature (Addis & Brouns, 2004) underline the need to engage in a critical reflection on the concept of

excellence as well as on the processes and procedures that lead to the creation and recognition of excellence. Excellence is the final result of procedures that place scientists and scientific institutions in different positions within the network and the hierarchy of their fields. The fact that women scientists do not achieve excellence at the same rate as would be predicted by their outputs in the earlier stages of their scientific career is the product of a number of social processes within and outside the scientific community.

Subtle gender discrimination

Gender discrimination in the scientific system is prohibited, but still exists, though it adopts more subtle forms than in the past. It may impact on the selection, hiring and promotion procedures, on the distribution of resources or on the assessment of scientific excellence.

As Husu (2005) stresses, gender discrimination in science may take different forms, sometimes overt, but most often subtle and hidden: recruitment to attractive temporary positions can take place unannounced and behind closed doors, which is favourable to an exclusive group of men; invitations to women can be 'forgotten' when there is a place as a keynote speaker at a conference. What is really happening may be that 'nothing happens' or that something that should take place in the career does not happen: not being seen, heard, read, cited, invited, encouraged. Consisting of non-occurrences, this kind of discrimination is hard to identify and challenge.

Subtle gender discrimination may operate even in highly formalised and seemingly gender-neutral peer-review processes or selection and promotion procedures. It is a well documented fact in psychosocial research that gender does matter in evaluation procedures. In spite of a general

move towards more equal gender relations and values, the majority of both men and women tend unconsciously to rate the quality of men's work higher than that of women when they are aware of the sex of the person to be evaluated, but not when the sex is unknown. Evaluation experiments show that changing the submitter's first name results in a significant difference in the scores assigned to identical documents (Steinpreis et al., 1999). Experiments conducted by Foschi (2000) show the pervasive, albeit unconscious, use of gender-based double standards, with stricter standards for women than for men.

Cumulative advantages and disadvantages

Merton (1968, 1988) coined the term 'Matthew effect' to describe the pattern of cumulative advantages in science ('For to all those who have, more will be given, and they will have abundance; but from those who have nothing, even what they have will be taken away'. Gospel of Matthew 25:29). The Matthew effect refers to the social processes through which initial advantages in terms of capacity, structural location and available resources make for successive increments in advantage such that the opportunities for undertaking scientific research and receiving symbolic and material rewards for its results tend to accumulate for some scientists and scientific organisations

The term 'Mathilda effect' was coined by Rositter (1993) to highlight the fact that gender discriminatory practices follow the same logic of cumulative advantages and disadvantages already explained by the Mathew effect. Following the same cumulative pattern, women's slight disadvantages in the early stages of the scientific career might turn into wide differences in career outcomes.

Gate-keeping

Gate-keepers are established scientists or peers that control the definition of merit and the means of exercising academic power (Merton, 1973). More generally, gate-keeping processes can aim to control or influence the entry or access to a particular arena, allocation of resources and information flows, the setting of standards, development of the field and the agenda, or the external image of that arena. Gate-keeping can function as exclusion and control, on the one hand but, on the other hand, it can also facilitate and provide opportunities and resources (Husu, 2004). It is argued that the fact that the gate-keepers of scientific research in Europe are white, middle-aged male academics restricts the possibilities of those individuals that do not conform to this profile (Osborn et al., 2000).

Political approaches to gender equality in science and technology

To better understand the complex processes involved in the increasing participation of women and minorities in science and technology, Schiebinger (2008b) identifies three interrelated political approaches:

- **Fixing the numbers of women in science:** The first of these approaches focuses on programmes targeting women themselves. It seeks to increase women's participation in science and technology by supporting women's educational opportunities and careers.
- **Fixing the institutions:** The second approach seeks to increase women's participation by reforming research institutions. Efforts in this field attempt to reform institutions that historically developed around the needs of male professionals with stay-at-home wives. Institutional reform ranges from

counteracting subtle gender and ethnic biases in hiring and promotion practices to restructuring work-life balance by offering parental leave, supporting child- and elder-care, and allowing for career breaks.

- **Fixing the knowledge:** The third focuses on overcoming gender bias by mainstreaming gender analysis into basic and applied research. Western science –its methods, techniques, and epistemologies– is commonly celebrated for producing objective and universal knowledge, transcending cultural restraints. With respect to gender, race, and much else, however, science is not value neutral. Research has documented how gender inequalities, built into society and research institutions, have influenced science and technology. Gender biases in research limit scientific creativity, excellence, and benefit to society.

These three approaches are interrelated: increasing women's participation in science and technology will not be successful without restructuring institutions and mainstreaming gender analysis into knowledge production.

Gender equality in European research policy

In 1996 the European Commission issued the Communication *Incorporating equal*

opportunities for women and men into all Community policies and activities. This was the first step towards the implementation of gender mainstreaming in the European Union.

The Amsterdam Treaty of 1997 laid the legal foundation for gender mainstreaming, namely in articles 2 and 3:

Article 2: The promotion of equality between men and women is a task of the European Community.

Article 3: In all its activities the European Community shall aim to eliminate inequalities and to promote equality between men and women.

In 1999 the European Commission issued the Communication *Women and Science: mobilising women to enrich European research*. This was the first step towards a gender equality policy in European research. Within FP5 (1998-2002) several efforts were made to promote gender equality in Framework Programme activities. This approach was broadened and reinforced during the implementation of FP6 (2002-2006), which established two main goals: a 40% target of women's representation in committees, groups and panels and the integration of the gender dimension in research content. FP7 (2007-2013) gives continuity to these two goals in order to foster scientific excellence.

INTRODUCTION

This is the synthesis report of the study *Meta-analysis of gender and science research* (RTD-PP-L4-2007-1), commissioned by DG Research to the consortium led by CIREM (Spain) and made up of Université Libre de Bruxelles (Belgium), Inova Consultancy Ltd. (United Kingdom), Fondazione Giacomo Brodolini (Italy), Bergische Universität Wuppertal (Germany) and Politikátörténeti Intézet KHT (Hungary).

The purpose of the study was to collect and analyse research on horizontal and vertical segregation in research careers, as well as the underlying causes and effects of these two processes.

The objectives of the study were to:

- Provide an exhaustive overview and analysis of research on gender and science carried out at the European, national, and regional levels.
- Make the study results accessible to researchers and policy-makers via an informed bibliography (online database) and a set of reports.
- Steer policy-making on gender and science and define future research priorities within the FP7, in particular through good practice examples and gap analysis in the various research topics.

For the purposes of the study, 'science' was understood in its broadest meaning, including social sciences and humanities as well as research and technological development. S&T (science and technology) is used throughout the text to refer to science *strictu senso* (mathematics, natural sciences, life sciences) and technology.

The study covered the research on gender and science produced between 1980 and 2008, in

all European languages, in 33 countries: the 27 EU Member States as well as 6 Associated Countries to the Seventh Framework Programme for Research and Technological Development (FP7) (Croatia, Iceland, Israel, Norway, Switzerland, and Turkey).

The online database (Gender and Science Database, GSD) and the reports are available at the website of the study: www.genderandscience.org

Concept and methodology

National experts in the 33 countries covered by the study were in charge of selecting the most important contributions to the national literature from 1980 onwards and preparing an informed bibliography, which included the bibliographical reference, English title and abstract, as well as additional codified information addressing thematic and methodological issues. National experts codified the publications according to the following conceptual dimensions and topics:

1. A first descriptive dimension dealing with the main trends as regards:
 - Horizontal segregation: the concentration of women and men in certain disciplines or institutional sectors.
 - Vertical segregation: the unequal position of women and men within the scientific hierarchy.
 - Pay and funding: the unequal pay and unequal access to research funding of women and men in science.
2. A second dimension dealing with the analysis of gendered structural social dynamics that are reproduced in scientific work:
 - Stereotypes and identity: gender stereotypes, the social construction of

Table 1. Topics and dimensions

Topics		Dimensions		
Policies towards gender equality in research	Horizontal segregation	Vertical segregation	Descriptive	
	Pay and funding			
	Stereotypes and identity		Structural social dynamics	Causes and effects
	Science as a labour activity			
	Scientific excellence		Scientific culture and institutional practices	
	Gender in research contents			

identity and their impact on educational and professional pathways.

- Science as a labour activity: gendered institutional constraints related to the gender division of labour, the organisation of scientific work and the structure of scientific careers.

3. A third dimension, dealing with the analysis of issues directly related to scientific culture and scientific institutional practices:

- Scientific excellence: gender bias in the definition, measurement and evaluation of excellence.
- Gender in research contents: the mainstreaming of sex and gender in scientific knowledge and technological development.

4. A fourth and last contextual dimension, dealing with the analysis of policies towards gender equality in research.

The meta-analysis of the literature was developed on a sequential basis. The national experts were in charge of preparing a national report giving a concise overview of the most important trends, findings and gaps in research on gender and science. The second stage was the preparation of country-group reports, dealing with similarities and differences across countries.

The third stage was the elaboration of topic reports, which were meant to offer a more systematic review of the literature concerned. Finally, the synthesis report provides a comprehensive overview of the overall endeavour to produce a meta-analysis of gender and science research across all countries and topics.

Experts

The study was only possible thanks to the participation of a large number of scientists:

- Coordination team: in charge of the management and scientific coordination of the study and the preparation of the thematic reports.
- Social sciences correspondents: national experts on gender and science, in charge of the national informed bibliography and the national reports.
- Bio-natural and technical expert group: an advisory group of gender-sensitive scientists in the field of mathematics, natural sciences, life sciences and engineering, in charge of discussing the thematic reports.
- Scientific steering committee: a multidisciplinary advisory group for scientific advice on the overall study.

Table 2. Experts involved in the study

Coordination team	
Ms. Maria Caprile (coord).	CIREM (Spain)
Prof. Elisabetta Addis	Fondazione G. Brodolini – Università di Sassari (Italy)
Prof. Cecilia Castaño	CIREM – UOC (Spain)
Ms. Marina Larios	Inova Consultancy Ltd. (United Kingdom)
Prof. Danièle Meulders	DULBEA – Université Libre de Bruxelles (Belgium)
Dr. Mária Palasik	Politikatörténeti Intézet KHT (Hungary)
Prof. Robert Plasman	DULBEA – Université Libre de Bruxelles (Belgium)
Dr. Seppo Roivas	University of Joensuu (Finland)
Prof. Dr. Felizitas Sagebiel	Bergische Universität Wuppertal (Germany)
Ms. Núria Vallès	CIREM (Spain)
Social sciences correspondents	
Prof. Elisabetta Addis	Italy
Ms. Aida Bagic	Croatia
Prof. Eva D. Bahovec	Slovenia
Prof. Doina Balahur	Romania
Ms. Maria Caprile	Spain
Dr. Hilde G. Corneliusen	Norway
Dr. Suzanne de Cheveigné	France
Dr. Maria José Gonçalves	Portugal
Dr. Agneta Hansson	Sweden
Dr. Ulrike Knobloch	Switzerland
Prof. Voldemar Kolga	Estonia
Dr. Alena Křížková	Czech Republic
Ms. Marina Larios	United Kingdom
Dr. Andrea Leitner & Dr. Angela Wroblewski	Austria
Dr. Laura Maratou-Alipranti	Greece & Cyprus
Prof. Danièle Meulders	Belgium
Prof. Lilja Mósésdóttir	Iceland
Ms. Elzbieta Pakszys	Poland
Dr. Mária Palasik	Hungary
Ms. Emma Parry	Ireland
Prof. Robert Plasman	Luxembourg
Dr. Jolanta Reingardé	Lithuania
Dr. Seppo Roivas	Finland
Prof. Dr. Felizitas Sagebiel	Germany
Dr. Nikolina Sretenova	Bulgaria

Prof. Mine Tan	Turkey
Prof. Mina Teicher	Israel
Mr. Jacob S. Thomsen & Ms. Lisbeth Dons Jensen	Denmark
Dr. Ilze Trapenciere	Latvia
Dr. Natasa Urbancíková	Slovakia
Dr. Marieke van den Brink	Netherlands
Prof. Mario Vassallo & Prof. Lydia Sciriha	Malta
Bio-natural and technical expert group	
Dr. Anna Maria Faisca	Portugal
Dr. Adina Magda Florea	Romania
Dr. Bojana Hamzic	Croatia
Dr. Dunja Mladenic	Slovenia
Prof. Nikitas Nikitakos	Greece
Dr. Birgitta Nordstrom	Denmark
Dr. Elizabeth Pollitzer	United Kingdom
Prof. Gulsun Saglamer	Turkey
Dr. Dalia Satkovskienė	Lithuania
Prof. Mina Teicher	Israel
Dr. Flavia Zucco (Rapporteur)	Italy
Scientific steering committee	
Prof. Francesca Bettio	Italy
Dr. Dóra Groó	Hungary
Dr. Ineke Klinge	Netherlands
Dr. Pilar López Sancho	Spain
Prof. Martine Lumbreras	France
Prof. Mary Osborn	US
Prof. Londa Schiebinger	US
Dr. Imrgard Schultz (Rapporteur topic reports)	Germany
Ms. Eleanor Tabi Haller-Jorden	Switzerland
Dr. Teresa Torns (Rapporteur country-group reports)	Spain
Prof. Sylvia Walby	United Kingdom

Table 3. Thematic reports

Country-group reports	Authors
Continental countries	Hafsatou Diallo, Danièle Meulders, Síle O’Dorchai & Robert Plasman
Eastern countries	Mária Palasik, Nikolina Sretenova, Robert Takács & Núria Vallès
Nordic countries	Seppo Roivas
Southern countries	Elisabetta Addis & Costanza Pagnini
United Kingdom and Ireland	Cinnamon Bennett, Marina Larios, Louise Norman & Emma Parry
Topic reports	Authors
Horizontal and vertical segregation	Danièle Meulders, Robert Plasman, Audrey Rigo & Síle O’Dorchai
Gender wage gap and funding	Danièle Meulders, Síle O’Dorchai, Robert Plasman & Audrey Rigo
Stereotypes and identity	Felizitas Sagebiel & Susana Vázquez-Cupeiro
Science as a labour activity	Maria Caprile & Núria Vallès
Scientific excellence	Elisabetta Addis with the assistance of Costanza Pagnini
Gendered innovations	Londa Schiebinger, Ineke Klinge, Addison Arlow & Sarah Newman
Policies towards gender equity in science and research	Cecilia Castaño, Jörg Müller, Ana González & Rachel Palmén

The table below provides the complete list of experts involved in the project (by role, in alphabetical order).

Thematic reports

The study produced five country-group reports and seven topic reports. All the reports are available at the website of the study.

Structure of the report

The results of our analysis are presented as follows: After this introduction, the first part provides an initial overview of the most important trends as regards gender

segregation in science and related research. It is a first approach to the literature analysed. The second part deals with the main results of the meta-analysis as regards gender differences in scientific careers, with a focus on three critical moments: choice of studies, which remains largely gendered; the ‘rush hour’, i.e. the early stage of the scientific career, in which family and career demands most often collide, a fact that disproportionately disadvantages women; and career advancement, which shows persistent gender inequality. The third part turns to an examination of scientific institutions and scientific knowledge, presenting the results of the meta-analysis for three different themes: current institutional change, gender analysis in

research content and policies towards gender equality in science. Finally, in the last part we present some concluding remarks and recommendations for further research.

The report aims to provide a comprehensive meta-analysis of the literature. While dealing with conceptual issues and methodological trends, it attempts to illustrate the main debates and findings through selected references to studies. These references are

not meant to be exhaustive, but rather indicative of the kind of research developed. Similarly, boxes are used throughout the text to examine specific issues in greater depth. They usually contain an abstract from the GSD or a quotation from a study of particular significance that illustrates what is discussed in the text. Finally, the report intends to present a synthesis of the results and, when necessary, refers the reader to the national or thematic reports for further details.

1

SETTING THE SCENE

1.1 Gender segregation in science

Most studies emphasise that gender differences in scientific careers are decreasing for recent cohorts. Women's and men's professional and family trajectories are more aligned with each other than ever (Alaluf et al., 2003b; Lind, 2006). This, however, does not mean that women have equal opportunities to attain academic status equal to that of men. The move towards gender equality in science cannot be taken for granted. Gender inequalities persist in education insofar as the gender ratio differs across fields of study. The existence of a 'glass ceiling' or a 'sticky floor' affects women trying to progress to senior positions. It affects all occupational sectors, even those which are dominated by women. The absence of women in leadership positions tends to be more acute in science and technology occupations than in other fields (Osborn et al., 2000). Gender segregation may be slowly eroding, but women are still

unable to fully develop a scientific career on equal terms with men. Thus, the literature on gender segregation in science shows two main concerns: First, research and technological development professions seem less responsive to the social forces that are successfully leading to progress towards gender equality in other highly skilled professions. And secondly, this trend is clearly at odds with the scientific ethos of universalism and meritocracy: if universalism and meritocracy were the actual rules, gender inequality would be less prevalent than in other professions.

This chapter provides an overview of trends in gender segregation in science. It starts with the analysis of recent trends in gender-based employment, with a particular focus on highly skilled professions. The next sections provide an account of the most relevant trends as regards segregation among researchers as well as gender differences in pay and access to research funding. The following section provides an overview of the structure of the

Box 1. Promoting excellence through mainstreaming gender equality: ETAN report

'Women constitute half the undergraduate population. However, there is a continuous drop in the numbers of women at each level of the academic ladder and many highly trained women are lost to science. Institutions that employ scientists tend to be behind the times in addressing the life/work balance and need to modernise.

Old-fashioned practices characterise employment and promotion procedures in some of our academic institutions. Reliance on patronage, the 'old boys' network' and personal invitations to fill posts cuts across fair and effective employment procedures. More sophisticated means of assessing merit are recommended.'

Osborn, M., Rees, T., Bosch, M., Ebeling, H., Hermann, C., Hilden, J., McLaren, A., Palomba, R., Peltonen, L., Vela, C., Weis, D., Wold, A., Mason, J. & Wennerås, C. 2000, *Science policies in the European Union: Promoting excellence through mainstreaming gender equality. A report from the ETAN Expert Working Group on Women and Science*, Office for Official Publications of the European Communities, Luxembourg, pp. viii-xix.

‘excellent’ scientific career and the diversity of research paths in both academic and non-academic settings, whilst the last section presents a critical reflection on the conceptual shortcomings of the ‘leaky pipeline’ approach for research and policy making on gender equality in science.

Gender segregation in employment

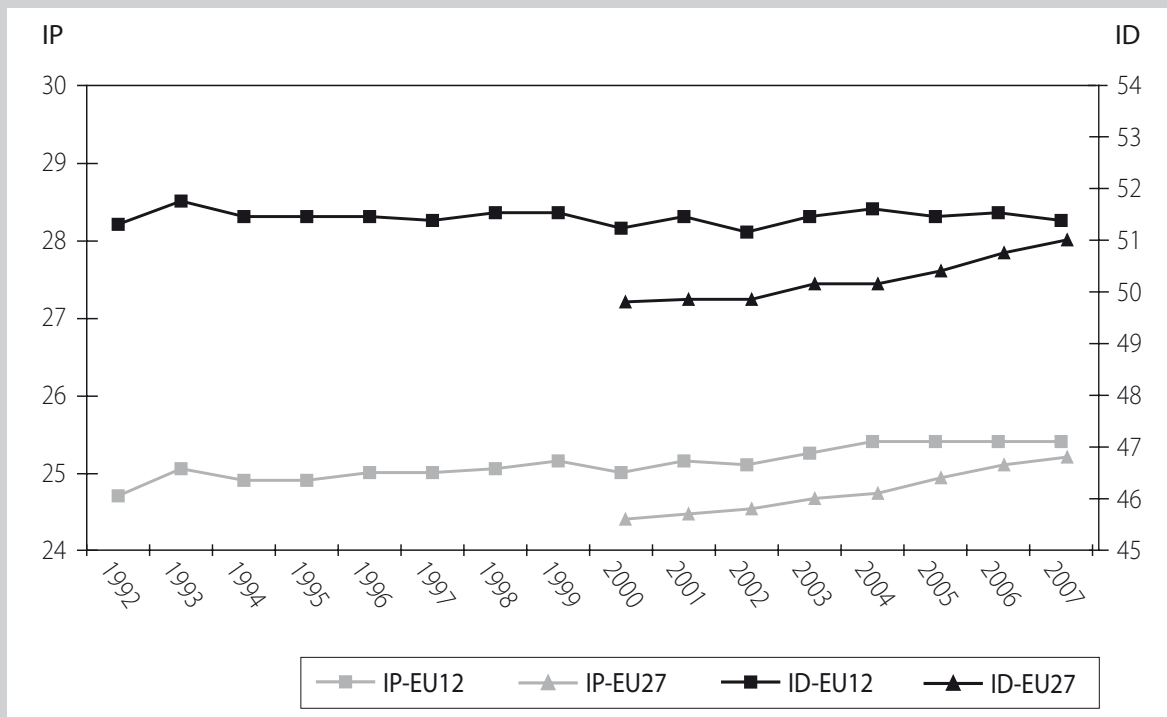
Gender segregation refers to the tendency of women and men to work in different occupations and sectors. It has long been acknowledged as a pervasive phenomenon

in all OECD countries (Anker, 1998; OECD, 1998; Rubery & Fagan, 1993). The literature usually distinguishes between different types of segregation. According to Bettio and Veraschagina (2009) horizontal segregation is understood as the under- (over-) representation of a certain group of workers in occupations or sectors not ordered by any criterion, whilst vertical segregation refers to the under- (over-) representation of a group of workers in occupations or sectors at the top of a ranking based on ‘desirable’ attributes –income, prestige, job stability, etc. Underrepresentation at the top of occupation-specific ladders was subsumed

Box 2. Trends in gender-employment segregation

Figure 1 shows the evolution of gender occupational segregation for the EU as a whole measured by two of the most commonly used indices (IP and ID) from the beginning of the 1990s onwards. Segregation remains high and has changed little since the early 1990s.

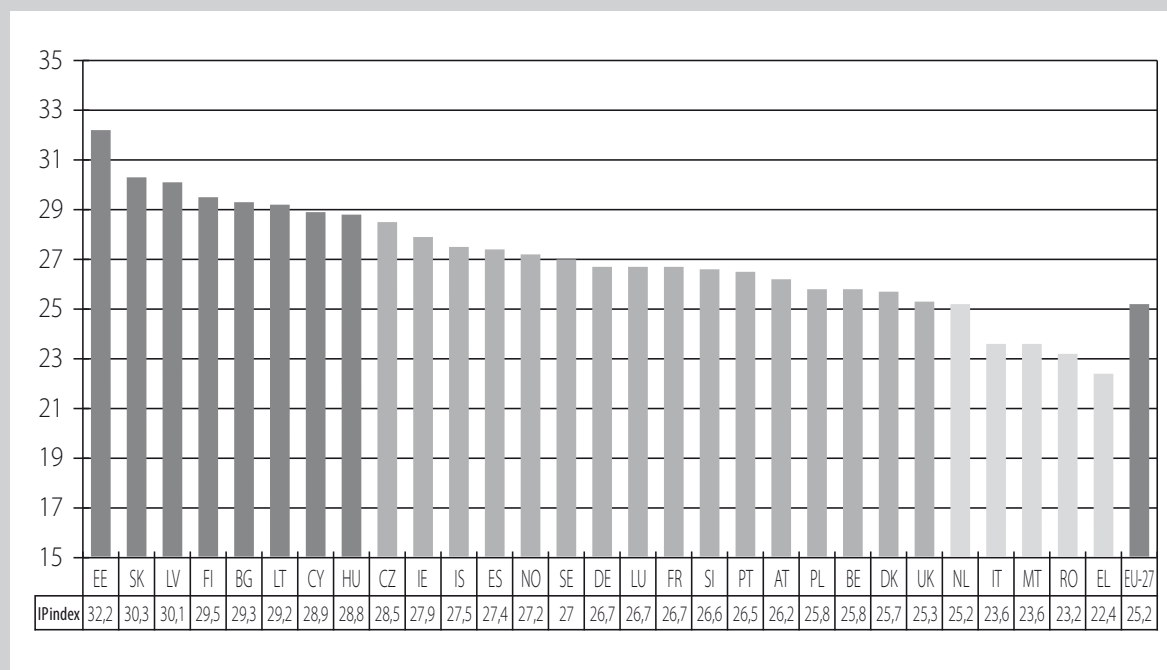
Figure 1. Gender occupational segregation in the EU, 1992–2007



Source: Bettio & Verashchagina (2009, p. 32).

Figure 2 presents gender occupational segregation in the different European countries in 2007. It shows that gender occupational segregation was 25% in 2007 in the EU on average (based on the IP index). The difference between the countries with the highest and lowest levels of segregation countries is about 10 percentage points. Patterns are similar for sectoral occupation.

Figure 2. Gender occupational segregation in Europe, 2007



Note: countries are grouped by level of the IP-index into high (black bar), medium (patterned bar) and low (grey bar). High (low) segregation countries score above (below) the EU average + (–) the mean absolute deviation.

Source: Bettio & Verashchagina (2009, p. 33) using LFS (ISCO-88 3-digit).

Bettio, F. & Verashchagina, A. (eds.) 2009, *Gender segregation in the labour market. Root causes, implications and policy responses in the EU*, Publications Office of the European Union, Luxembourg.

under the heading of ‘vertical segregation’, whereas it is now more commonly termed ‘hierarchical segregation’. In the literature, vertical segregation is referred to as the ‘glass ceiling’, which points to the existence of visible or invisible obstacles that lead to a certain scarcity of women not only in power and decision-making positions in public organisations and enterprises, but also in other types of organizations and trade unions (Laufer, 2002). This phenomenon of existing barriers that prevent the ascent of

women is completed by the concept of the ‘sticky floor’, which describes the forces that tend to maintain women at the lowest levels in the organisational pyramid (Maron & Meulders, 2008).²

Bettio and Verashchagina (2009) provide a comprehensive picture of recent trends in gender-based employment segregation in EU

⁽²⁾ Segregation can be measured in different ways. For a comprehensive description of different indices, see Meulders et al., 2010a.

countries. The evolution over the last 20 years points towards unchanging if not rising levels of segregation, although with significant variation across countries. 'Whether occupational or sectoral segregation is considered, the same four countries belong to the high- and the low-segregated group, respectively. The four high-segregation countries are Estonia, Slovakia, Latvia and Finland, and the four low-segregation countries are Greece, Romania, Malta and Italy' (p. 7). Trends show a positive correlation between segregation and women's employment rate in the short and medium term, with divergent de-segregation and re-segregation tendencies: 'A commonplace feature of employment segregation in Europe before enlargement was the paradox whereby Scandinavian countries recorded some of the highest levels of segregation, whilst the Mediterranean countries exhibited surprisingly low levels. This picture has changed over the past decade, not only because of enlargement but also thanks to some convergence across countries. Nordic and Scandinavian countries have recorded relatively fast de-segregation, whereas most Mediterranean countries, together with a few Eastern European countries, have actually experienced an increase in segregation. Desegregating countries include Sweden, Norway, Denmark, the UK, Austria, the Czech Republic and Iceland, whereas re-segregating countries include Romania, Bulgaria, Italy, Ireland, Latvia and Spain' (p. 32). There is thus no evidence of a spontaneous movement towards less segregation on all European labour markets.

Several theories attempt to explain the different situation of men and women in the labour market: the neo-classical theories based on the determinants of labour supply and demand, the institutional theories based on labour market segmentation and on the role of institutions, and finally, the radical and gender theories based on the hypothesis

that a certain type of worker is in demand in the labour market while others are excluded (Meulders et al. 2010a).

The recent EU report by Bettio and Verashchagina (2009, p. 45) summarises the scientific debate on gender segregation in this way: 'The debate over the roots of segregation dates back to the 1970s, but it remains the point of reference despite the fact that so much has changed since then. After decades of research, most scholars would agree that there can be no single-factor explanation for segregation. Given the widespread enforcement of equality legislation over the past years, the impressive advances of women in education, the progressive loss of importance of physical attributes for productivity, the change in family roles and, last but not least, the successful challenging of gender norms by feminism, current research has both narrowed down the list of potentially relevant factors identified in the early debate and nuanced the original explanations. Priority is given to four sets of factors: hours of work, stereotypes, choice of study field in education, and covert barriers and biases in organisational practices, including collective bargaining procedures'. The main findings of their study can be summarised as follows (p. 45):

- 'There is both statistical and qualitative (case-study) evidence that choice of study field still matters for the type of occupations that men and women enter, but the correspondence between field of study and occupation is close for only about 10 % of jobs –those in the licensed professions.
- Stereotypes are ubiquitous and continue to influence behaviour, but it is not easy to pinpoint the extent to which they represent genuine preferences, to what extent they express social norms and to what extent they are used to surrogate information. Also, the actual role they play in segregation

may be overestimated by qualitative research, since they are sometimes used to rationalise or even legitimise ex-post choices that may have been made on other grounds.

- The unequal care burden and the consequent inability to prioritise income commitment within the family drive the quest of many women for shorter and more flexible work hours. Among qualified women (the 'professionals') this search for hour-friendly occupational niches often either results in re-segregation into professional niches or hinders entry into occupations featuring high/irregular work hours and workload.
- When the search for shorter working hours leads to the choice of part-time work it is likely to further restrict the choice of occupation, as underlined by the significant increase of segregation that has been found in female part-timers in comparison with female full-timers.
- Although legal barriers to entry or restrictive practices have long been outlawed, covert biases or forms of impediments still exist, often restricting career paths and career

prospects within occupations. Examples that bear special importance for vertical or hierarchical segregation are closer rungs on ladders in the career tracks of feminised jobs, discretionary managerial practices in selection, hiring and promotions, networking and mechanisms of co-optation.

- All these mechanisms interact with different payment structures or different types of employers (large/small, private/public) in shaping the pattern of segregation.
- In highly paid professional occupations there is evidence that the influence of the above-mentioned factors of segregation is diminishing, especially among younger cohorts of women. This is not the case for low-paid occupations'.

The literature shows that gender segregation is less severe among highly qualified professionals than among the labour force as a whole. In the majority of EU countries the distribution of highly qualified women and men over the different occupations and sectors of economic activity is more balanced than for the entire labour force (Meulders et al., 2010a; see box 3 for further details).

Box 3. Occupational and sectoral segregation in the highly qualified workforce

The table below presents the values of the ID index measuring occupational segregation (ISCO88, 3 digits) and sectoral segregation (Nace.Rev.1, 1-digit) for three populations: the total workforce, the highly qualified workforce (university degree holders: ISCED 5A, 5B and 6) and the most highly qualified workers (PhD holders: ISCED 6) for all members of the EU-27 for 2007. Occupational segregation should be understood as a different distribution of male and female workers over the different occupations. Sectoral segregation should be understood as a different distribution of male and female workers over the different sectors of economic activity.

The table shows that occupational segregation in the highly qualified workforce is lowest in Spain, Cyprus, Belgium, Greece, Luxembourg and the Netherlands and highest in Italy, Romania and Bulgaria. In 19 countries, the ID index is lower among the highly qualified

workforce than on the labour market as a whole and it drops even further when one compares the highly qualified workforce with the subsample of the PhD holders. In a second group including France, Italy, Romania and Bulgaria, the level of dissimilarity in the distribution over professional categories is higher when only university holders are concerned than when the total labour force is analysed. In all of these countries, the ID index is lower amongst the PhD holders than amongst all the university degree holders. In Cyprus, Slovakia, Greece, and to a smaller extent in Estonia, professional dissimilarity is highest in the total workforce and lowest among university degree holders, with intermediate values for PhD holders.

**ID-index for occupational and sectoral segregation:
comparison of ISCED 5 & 6 holders with the total workforce, 2007**

	Occupational segregation			Sectoral segregation		
	Total population	ISCED 5 & 6 holders	ISCED 6 holders	Total population	ISCED 5 & 6 holders	ISCED 6 holders
AT	0.49	0.30	0.27	0.41	0.31	0.25
BE	0.45	0.26	0.14	0.28	0.32	0.14
BG	0.47	0.55	0.33	0.29	0.29	0.32
CY	0.46	0.25	0.34	0.30	0.26	0.56
CZ	0.52	0.32	0.20	0.31	0.34	0.30
DE	0.47	0.35	0.32	0.31	0.33	0.30
DK	0.46	0.33	0.19	0.40	0.42	0.19
EE	0.57	0.37	0.57	0.36	0.29	0.50
ES	0.47	0.24	0.12	0.39	0.24	0.13
FI	0.55	0.40	0.15	0.39	0.34	0.25
FR	0.33	0.34	0.16	0.34	0.29	0.19
GR	0.40	0.26	0.29	0.28	0.23	0.16
HU	0.52	0.36	0.27	0.46	0.28	0.41
IE	0.51	0.37	0.12	0.42	0.40	0.11
IT	0.39	0.48	0.13	0.27	0.34	0.10
LT	0.53	0.29	0.12	0.32	0.35	0.17
LU	0.45	0.27	0.10	0.32	0.24	0.20
LV	0.52	0.31	0.25	0.38	0.29	0.32
NL	0.46	0.27	0.19	0.41	0.32	0.29
NO	0.47	0.35	0.09	0.40	0.37	0.14
PL	0.42	0.34	0.26	0.26	0.30	0.22
PT	0.47	0.29	0.14	0.40	0.30	0.12
RO	0.39	0.52	0.24	0.20	0.24	0.23
SE	0.47	0.45	0.11	0.41	0.35	0.16
SI	0.42	0.41	0.19	0.28	0.30	0.15
SK	0.54	0.40	0.44	0.32	0.34	0.52
UK	0.49	0.35	0.11	0.37	0.36	0.14

Note: the figures for PhD degree holders should be interpreted with caution due to small sample sizes.

Source: Meulders et al, 2010a, on the basis of LFS 2007 calculations.

Trends are similar for sectoral segregation. Sectoral segregation in the highly qualified workforce is lowest in Greece, Spain, Luxembourg and Romania and highest in Ireland and Denmark. In 12 countries, the ID index is lower among the highly qualified workforce than on the labour market as a whole and it drops even further when one compares the highly qualified workforce with the subsample of the PhD holders. This pattern is mainly observed in the old EU-15 member states. In a second group, the level of dissimilarity in the distribution over the different sectors of activity is higher when only university degree holders are concerned than when the total labour force is analysed. This is the case in Romania, Poland, Slovenia, Belgium, Germany, the Czech Republic, Italy, Slovakia, Lithuania and Denmark. In all of these countries except for Romania and Slovakia, the ID index is lower amongst the PhD holders than amongst all the university degree holders. In Cyprus and Estonia, sectoral dissimilarity is highest between the PhD holders. Finally, in Hungary, Bulgaria and Latvia, the index is smaller among the university degree holders than in the total workforce but it rises between the university degree holders and the subcategory of the PhD holders.

Meulders, D., Plasman, R., Rigo, A. & O'Dorchai, S. 2010, Horizontal and vertical segregation. Meta-analysis of gender and science research – Topic report. Downloaded on 16/11/2010, available at: http://www.genderandscience.org/doc/TR1_Segregation.pdf

Trends of gender segregation in science

Over the last decades, the rising proportion of women in higher education and in highly skilled employment has triggered a major structural change in the labour market. However, this phenomenon has not translated into a similar rise in the participation of women in traditionally male-dominated scientific and professional fields. Women remain more severely underrepresented among researchers than among highly qualified professionals, as shown in the figure below (Figure 1).

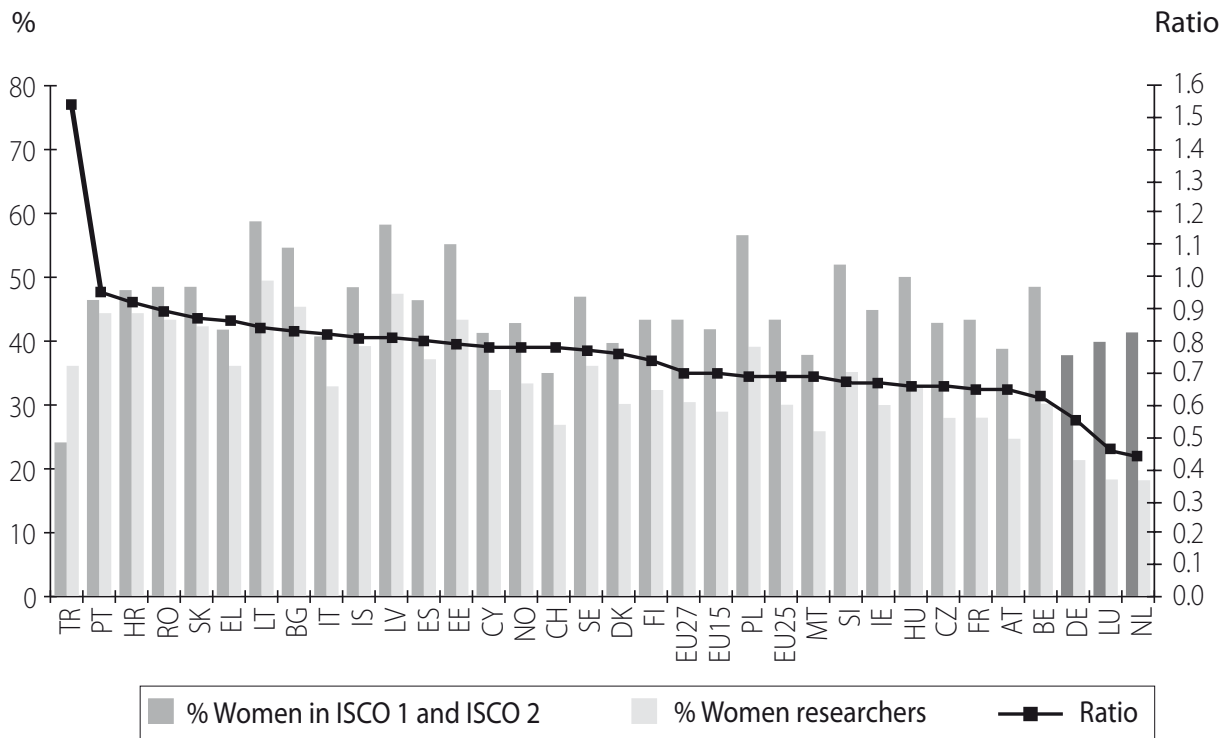
Research shows that gender segregation in science is driven by the same root causes as gender segregation in the labour market as a whole: gender stereotypes, choice of study field, gender division of labour and time constraints, and covert barriers and biases in organisational practices. In general, the influence of these factors

seems to be diminishing among the younger cohorts of highly qualified women (Bettio & Verashchagina, 2009).

The report by Meulders et al. (2010a) provides an overview of recent trends in gender segregation in science, based on the data gathered in *She Figures* (EC 2004 and 2009a). It shows that gender segregation is eroding, but only at a slow pace. Although in some countries the situation is more favourable for younger generations of women, there is no evidence of an automatic move towards gender equality in science.

Women in scientific research remain a minority, accounting for 30% of researchers in the EU in 2006. However, their proportion is growing faster than that of men (6.3% annually over 2002-2006 compared with 3.7% for men). It is also a positive trend that women's compound annual growth rate is higher among researchers than among highly educated professionals and technicians (5.4% for women and 3.9% for

Figure 1. Proportion of women among highly qualified professionals and researchers (latest available year)



Source: LFS 2009 and She Figures 2009 (EC, 2009a), own estimations.

men over the period 2002-2007). On average in the EU-27, women represent 37% of all researchers in the higher education sector, 39% in the government sector and 19% in the business enterprise sector: in all three sectors, however, there is a move towards a more gender-balanced research population.

In the EU-27, 45% of all PhD graduates in 2006 were women; they equalled or outnumbered men in all broad fields of study, except for science, mathematics and computing (41%), and engineering, manufacturing and construction (25%). In the majority of countries, the compound annual growth rate of female PhD graduates exceeded that of men in the period 2002-2006. On average in the EU-27, the number of female PhD graduates increased at a rate of 6.8% per year compared to 3.2% for male PhD graduates. Furthermore, the compound annual growth rate has significantly risen over time (it was 4.8 for women and 2.4

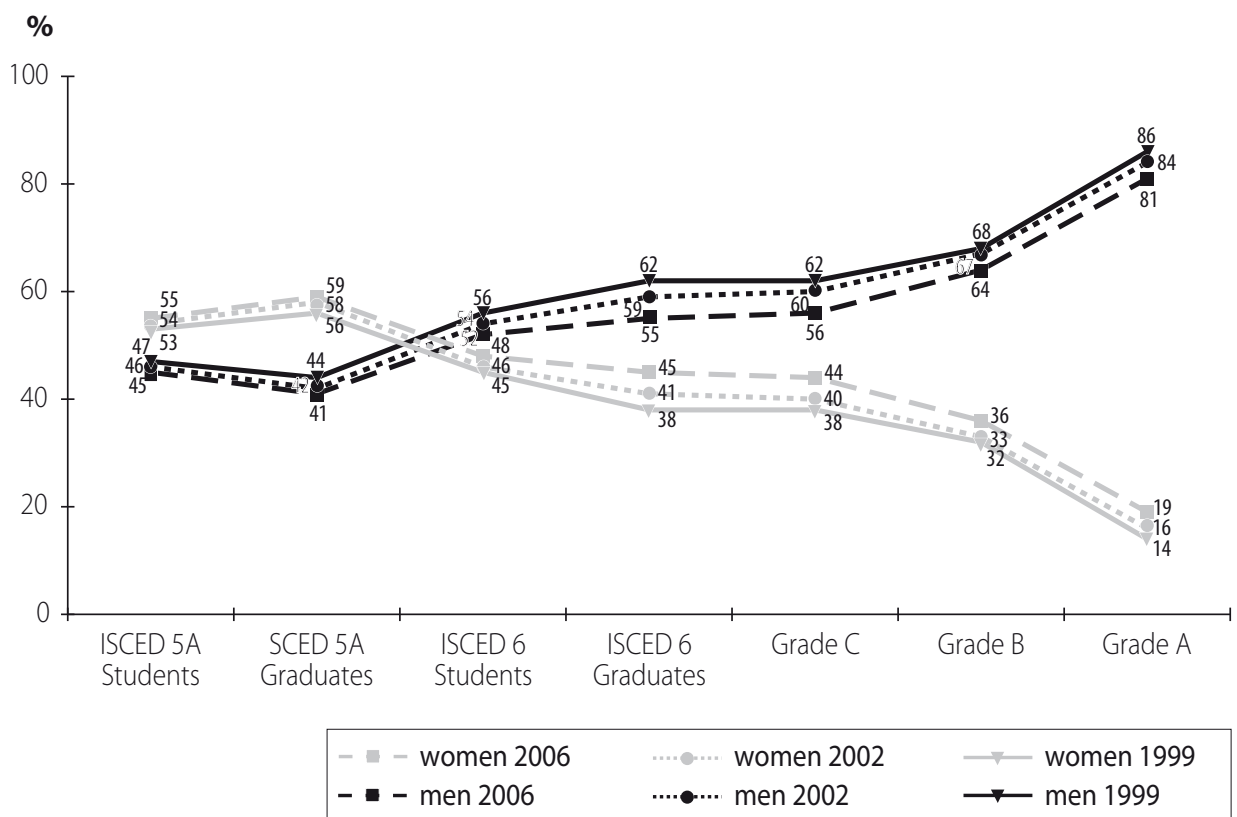
for men over the period 1998-2001). It is also worth noting that women's share among PhD graduates has increased in all fields of study, including those more male-dominated (more than 4 percentage points in science, mathematics and computing and engineering, manufacturing and construction in the period 2001-2006). According to Bettio and Verashchagina (2009), most European countries have experienced a steady desegregation trend in university education (graduate and PhD degrees) over the last decade, although with significant exceptions (particularly, Portugal, Spain, Italy, Belgium and the Czech Republic).

Very little is known about vertical segregation in the private sector. However, it is well documented that women's academic career remains markedly characterised by strong vertical segregation, with only slow improvement in women's relative position in

the period 1999-2006 (see figure 2). While in 2006 the proportion of female students and graduates exceeded that of male students, men outnumbered women among PhD students (48%) and PhD holders (45%). Women represent 44% of grade C academic staff, 36% of grade B academic staff and 18% of grade A academic staff.

Vertical segregation is a common trend in all EU countries and scientific disciplines, although variation is considerable in terms of both scientific disciplines and national contexts. Contrary to what may be expected, gender inequality in career advancement appears to be greater in the most female-dominated fields of science. A critical mass

Figure 2. Proportions of men and women in a typical academic career (students and academic staff), EU-27, 1999, 2002, 2006



Source: *She Figures 2003* (EC, 2004, p. 55), *She Figures 2009* (EC, 2009a, p. 73), on the basis of the Education Statistics (Eurostat); WiS database (DG Research); Higher Education Authority for Ireland (Grade A).

Exceptions to the reference year(s): ISCED 5A Graduates 2002: DK (2003), FR (2003); ISCED 6 Graduates 2006: IT (2004), 2002: DK (2003), FR (2003), RO (2003); WiS 2006: EE (2004), IE (Grade A: 2002-2003), EL (2000), MT (2004), PT (2003), SI (2007), SK (2007), FI (2007); 2002: IE (2004), EL (1999), NL (2003), UK (2003).

Data unavailable: ISCED 6 students 2006: DE, LU; 2002: DE, LU, RO, SI; ISCED 5A - 6 Graduates LU; WiS 2002: LU, IE (2004 - no grade A); Grade C unavailable: BG, RO (included in B).

Break in series: CZ (2005).

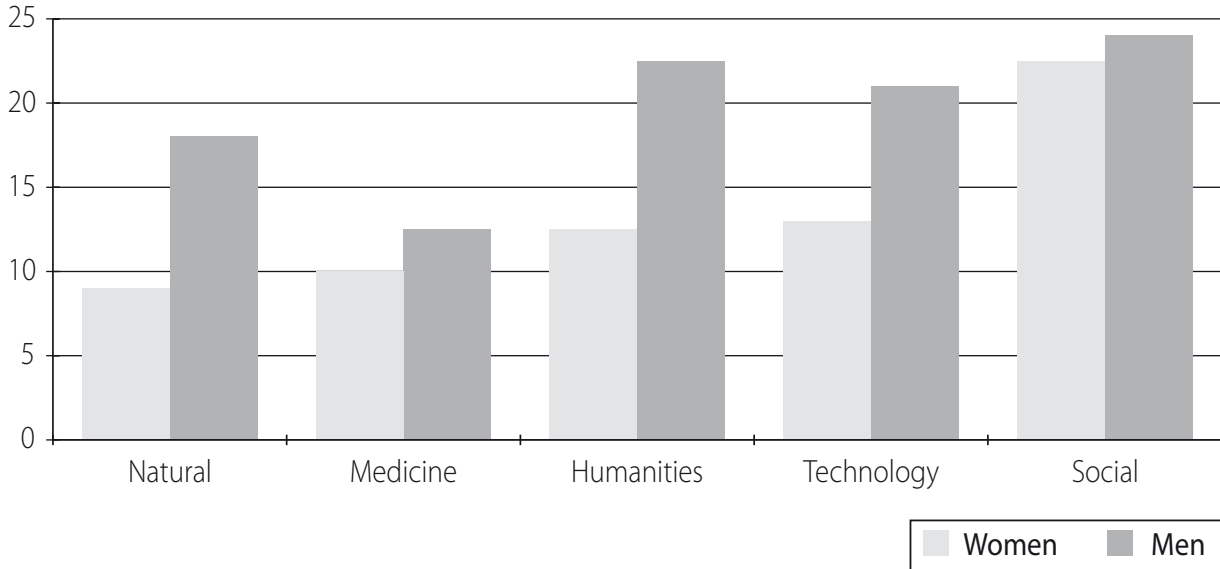
Provisional data: ES.

Data estimated: EU-27 (by DG Research) for WiS, ISCED 6 students, ISCED 5A-6 graduates; SI. Head count (Grades A, B, C).

NO: before 2007 biannual data.

Definition of grades: A: The single highest grade/post at which research is normally conducted. B: Researchers working in positions not as senior as top position (A) but more senior than newly qualified PhD holders. C: The first grade/post into which a newly qualified PhD graduate would normally be recruited. ISCED 5A: Tertiary programmes to provide sufficient qualifications to enter advanced research programmes & professions with high skills requirements. ISCED 6: Tertiary programmes which lead to an advanced research qualification (PhD).

Figure 3. Proportion of women and men younger than 60 years appointed as professors in Sweden within 18 years of receiving a PhD among those who took the degree between 1980 and 1985



Source: Högskoleverket (2006), quoted in Bettio & Verashchagina (2009, p. 68).

Figure 4. Proportions of men and women in a typical academic career in Finland and Denmark, 1999-2007



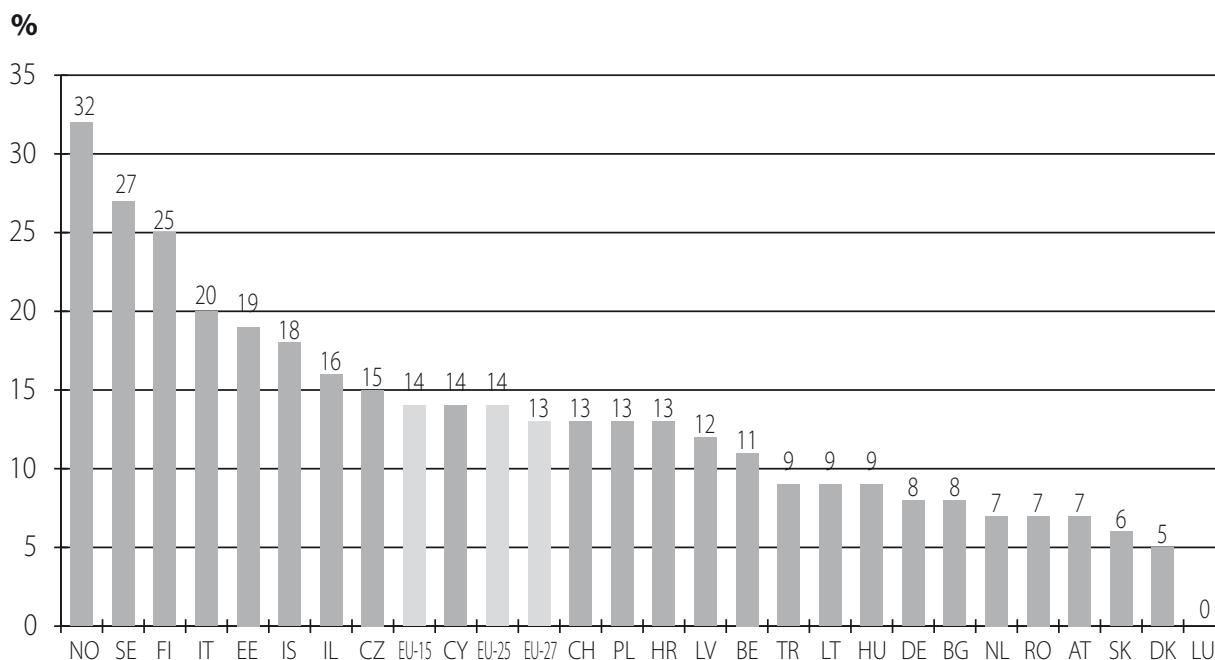
Source: *She Figures* (EC, 2004 and 2009a).

Definition of grades: A: The single highest grade/post at which research is normally conducted. B: Researchers working in positions not as senior as top position (A) but more senior than newly qualified PhD holders. C: The first grade/post into which a newly qualified PhD graduate would normally be recruited.

of women among students and young researchers does not entail more equal proportions of women and men in the highest scientific positions. In other words, vertical segregation is greater in the most female-dominated areas (e.g. de Henau & Meulders, 2003), a fact supported by longitudinal data. Figure 3 shows the proportion of women and men appointed as professors within 18 years of receiving a PhD among those who took the degree between 1980 and 1985. It shows that women face more difficulties than men in obtaining a professorship in all scientific fields, although with significant variation. The gender gap is largest in humanities, one of the most female-dominated fields, followed by technology, one of the most male-dominated, whilst women fare best in social sciences.

Cross-national variation is also considerable and suggests that academic systems may offer more or fewer opportunities to women. Figure 4 illustrates the striking differences between Denmark and Finland, two countries with a similar background in terms of gender equality and socioeconomic policies. In Finland, the proportion of women and men in academic positions is similar, with the exception of full professors. In contrast, inequality in Denmark is already pronounced at PhD level and increases steadily as one ascends the academic ladder (Roivas, 2010). It is but one example of the extent to which national differences in the proportion of women along the academic ladder does not correlate neatly with the overall presence of women in the labour market or the extent of gender equality policies, a fact that has been

Figure 5. Proportion of female heads of institutions in the HES, 2007



Source: *She Figures 2009* (EC, 2009a, p. 97), on the basis of the WiS database (DG Research).

Exceptions to the reference year: IT: 2009; BE (Dutch-speaking community), DE, EE, HU, AT, PL, SK, FI, SE, HR, CH, IL: 2008; DK, CY: 2008/2007; RO: 2007/2006.

Data unavailable: BE (French-speaking community), IE, EL, ES, FR, MT, PT, SI, UK.

Data estimated: EU-27, EU-25, EU-15 (by DG Research).

BE data refer to Dutch-speaking community.

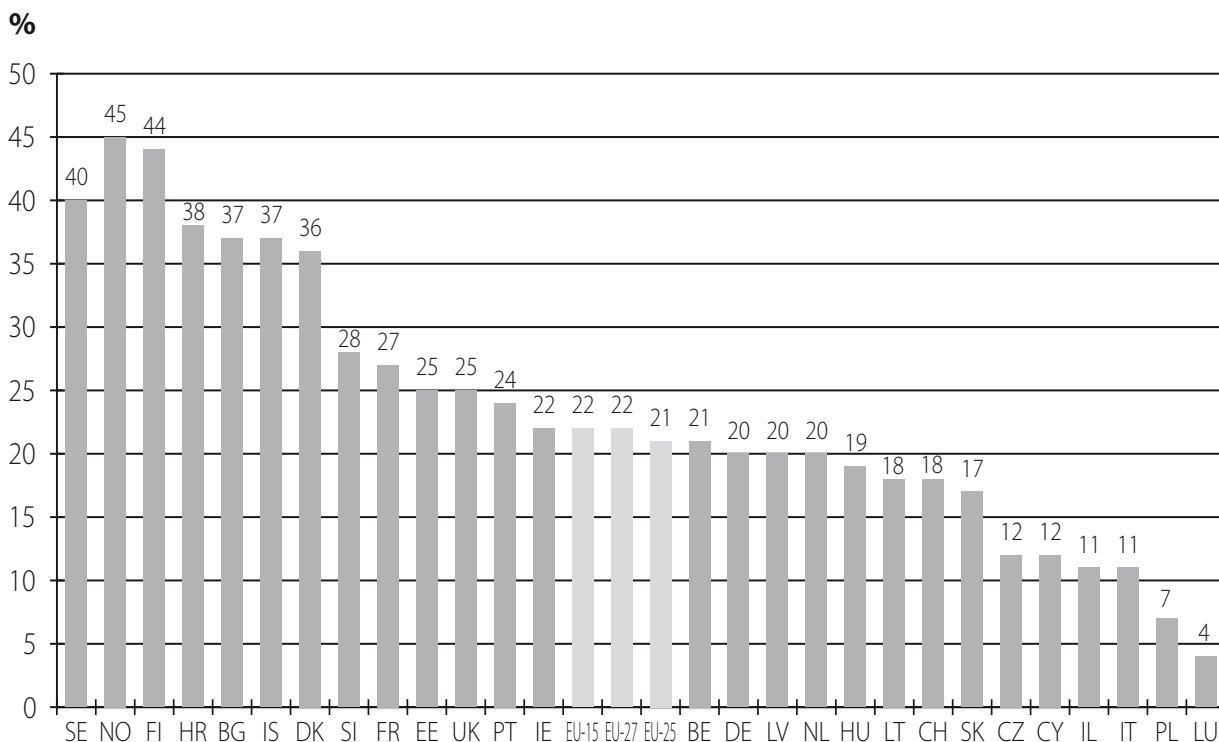
extensively addressed in the country group reports (see Addis & Pagnini, 2010; Roivas, 2010; Sretenova, 2010).

Overall, the underrepresentation of women on scientific decision-making committees and in leadership positions is even more marked. As shown in figure 5, on average throughout the EU-27, only 13% of institutions in the higher education sector were headed by women in 2007. National variation is considerable (from 27% to 0%). The countries that show the highest proportion of women are Norway, Sweden, Finland, Italy and Estonia (more than 19%). When comparing these results to the proportion of women in grade

A positions, it is obvious that the proportion of women continues to decline as one advances up the academic ladder.

The proportion of women on boards adds interesting information to this overall pattern. In general, boards' data covers scientific commissions, R&D commissions, boards, councils, committees and foundations, academy assemblies and councils, as well as different field-specific boards, councils and authorities. These boards exercise crucial power of influence on the orientation of research. Figure 6 presents data on the proportion of women on boards for the year 2007. For the EU-27 average, this proportion was 22% for

Figure 6. Proportion of women on boards, 2007



Source: *She Figures 2009* (EC, 2009a, p. 99), on the basis of the WiS database (DG Research).

Exceptions to the reference year: CZ, SK, IL: 2008; IT: 2005; IE: 2004; PT: 2003; FR, PL: 2002.

Data unavailable: BE (Dutch-speaking community), EL, ES, MT, AT, RO, TR.

Data estimated: EU-27, EU-25, EU-15 (by DG Research).

Some differences exist in coverage and definitions between countries.

The total number of boards varies considerably among countries.

BE data refer to the French-speaking community.

Table 4. Gender pay gap in % by selected occupations for employees in private enterprises and the public sector, EU-27, 2002 and 2006

ISCO CODES		Private enterprises		Public sector		Private enterprises and public sector	
		2002	2006	2002	2006	2002	2006
100	Legislators, senior officials and managers	29	30	22	28	29	30
110	Legislators, senior officials and managers	u	U	—	—	u	u
120	Corporate managers	28	30	—	—	28	30
130	Managers of small enterprises	32	28	—	—	u	u
200	Professionals	31	29	46	38	34	31
210	Physical, mathematical and engineering science professionals	22	22	42	29	25	23
220 230 240	Life science, health, teaching and other professionals	36	33	42	40	38	34
300	Technicians and associate professionals	28	26	36	27	28	26
310	Physics and engineering science associate professionals	26	25	35	25	27	25
320 330 340	Life science, health associate, teaching associate professionals and other associates professionals	30	28	40	32	31	28

Source: *She Figures 2009* (EC, 2009a, pp. 88-89), on the basis of the SES 2002 and 2006 (Eurostat).

'u': unreliable due to small sample size. Gender pay gap (unadjusted) = Difference between average gross hourly earnings of male paid employees and of female paid employees as a percentage of average gross hourly earnings of male paid employees.

that year, but again national variation is striking (from 49% to 4%). In Sweden, Norway and Finland, the share of female board members exceeds 44%, a fact that reflects the fact that national legislation in these countries establishes the obligation to have at least 40% of members of each sex on all national research committees and equivalent bodies.

The persistence of vertical segregation preventing women from reaching the top echelons of their scientific field means that women are scarce in the most prestigious

institutions, where only excellent scientists congregate to lead their disciplinary field. As documented in Addis (2010), the presence of women scientists in the National Academies is often less than 10%.

Gender pay gap

The report on pay and funding by Meulders et al. (2010b) shows that there is a persistent gender pay gap in all countries in the labour market in general and also in scientific and

research occupations. There is no reliable evidence that the pay gap is closing. The increase in the level of women's qualifications observed over the last decades has not led to a proportional reduction of the pay gap. The gender pay gap among scientists can be seen in part as a consequence of gender segregation. Vertical segregation has a direct impact on the gender pay gap because of the fact that women are underrepresented in leadership positions. Horizontal segregation also has an impact on the gender pay gap since women are underrepresented in the most prestigious and the most highly-paid occupations and sectors. However, differences in the working time arrangements of men and women, differences in terms of extra pay and bonuses, problems with the conciliation of work and private life and (direct or indirect) discrimination also lead to pay differences.

She Figures 2009 (EC, 2009a) shows that the gender pay gap is higher for higher qualified professions than in the labour market as a whole and it is higher in occupations where highly qualified female professionals are better represented. On the basis of the data provided by the Structure of Earnings Survey (SES) (2006), the average EU25 gender pay gap was 25% for the entire labour market. As can be seen in table 4, the gap was 31% for professionals (ISCO 88 major group 2) with significant variation: 23% for physics, mathematics, engineering and science professions (the most male-dominated) and 34% for life sciences, health, teaching and other professions (more female-dominated).

Table 4 also shows that for the category of professionals (ISCO 200) and technicians (ISCO 300) the pay gap appears to be wider in the public than in the private sector. As *She Figures* (EC, 2009a, p. 72) contends, 'this finding can be surprising given that it is generally believed that the stronger regulation in the public sector better protects women against discrimination. This is thus not certified by

our data which could tentatively lead towards a different explanation: Could it be that private enterprise is more efficient than the public sector and as such cannot go without recruiting bright women and appreciate their true worth in their pay?'

Table 5 breaks down the gender pay gap into 4 different age groups for employees in private and public enterprise for the total of occupations 100, 200 and 300. In the EU-27, in 2006, the gender pay gap was widest for 45-54 year-olds (38%) and 55-64 year-olds (37%). It was approximately 10 percentage points narrower amongst 35-44 year-olds (28%) and 20 percentage points narrower amongst 15-34 year-olds (17%). At all ages, but more particularly for prime-age workers (35-54 years of age), the gap narrowed between 2002 and 2006. The general tendency was similar to that observed in the labour market as a whole: the pay gap widens with the age of researchers.

Table 5. Gender pay gap in % by age group for employees in the private and public sectors for the total of occupations 100, 200 and 300, EU-27 and EU-25, 2002 and 2006

		2002	2006
EU-27	15-34	19	17
	35-44	32	28
	45-54	43	38
	55-64	38	37
EU-25	15-34	18	17
	35-44	30	26
	45-54	41	36
	55-64	37	37

Source: *She Figures 2009* (EC, 2009a, p. 91), on the basis of the Structure of Earnings Surveys 2002 and 2006 (Eurostat).

Notes: Gender pay gap (unadjusted) = Difference between average gross hourly earnings of male paid employees and female paid employees as a percentage of the average gross hourly earnings of male paid employees.

O'Dorchai (2010) provides a further analysis of the structure of earnings survey data which goes into cross-country differences to test some of the results of *She Figures* (see box 4 for further details):

- The gender pay gap for highly qualified professions shows considerable cross-national variation. It ranges from 4% in Romania to 34% in Germany for legislators and senior managers (ISCO88 major group 1); from 1% in Belgium to 27% in Hungary and Estonia for professionals (ISCO88 major group 2) and from 8% in Luxembourg to 36% in Cyprus for technicians (ISCO 88 major group 3).
- Women's pay is further behind men's in female-dominated occupations in some countries, but in others the opposite is the case: In Belgium, Latvia, Lithuania, Norway, Hungary, Slovakia, the UK, the Czech Republic, Estonia, Finland and Germany, the gender pay gap is higher in male-dominated occupations.
- When the public subsectors less related to science and research are excluded from the analysis (administration, defence and compulsory social security), the total gender pay gap turns out to be slightly wider in the private than in the public sector. This trend, however, is not consistent across countries.
- There is no general tendency towards an increase in the gender wage gap as age rises, although in all countries the gender wage gap is narrower in the 20-29 year age group than in the others.

Box 4. The gender pay gap in research: a comparison of 23 European countries

The gender wage gap is in a sense the final and most synthetic indicator of all inequalities between male and female researchers that structure the labour market. Even though research generally concerns the most highly educated fragment of the workforce, of all countries observed in *She Figures 2009*, there is none where female wages are equal to men's, despite the almost universal existence of legislation to impose gender wage equality. This paper uses European Structure of Earnings data for 2006 for 23 European countries (BE, BG, CY, CZ, DE, EE, ES, FI, FR, EL, HU, IT, LT, LU, LV, NL, PL, PT, RO, SE, NO, SK, UK) to compute the gender pay gap within three occupational groups in private and public enterprise and for different age groups (14-19 years, 20-29 years, 30-39 years, 40-49 year, 50-59 years and 60+ years) and working hours (part-time versus full-time). The first group selected relates to decision-making occupations (ISCO 100 – Legislators, senior officials and managers). The second group refers to 'professional' occupations (ISCO 200) and the third to 'technical and associate professional' occupations (ISCO 300).

A first question the paper set out to answer was that of a wider gender pay gap in those occupations that are most open to high-level female researchers. Women's pay is more behind men's in female-dominated occupations in Romania, Luxembourg, Bulgaria, Cyprus, France, the Netherlands, and Sweden. In those countries, it probably holds true that the few men who work in female-dominated occupations hold the highest responsibility posts and are thus comparatively better rewarded. In Belgium, Latvia, Lithuania, Norway, Hungary, Slovakia, the UK, the Czech Republic, Estonia, Finland and Germany, the gender pay gap is higher in male-dominated occupations. This could point towards a situation where the

organisational culture shows resistance towards integrating women. The reference model in this occupation is defined in terms of masculine attributes. Women are consequently employed at lower levels and in lower pay jobs.

A second question addressed in this paper is that of an increasing gender pay gap by age. Although we fail to show a general tendency towards an increase in the gender wage gap as age rises, it is true that the gender wage gap is smaller in the 20-29 age group than in the others. However, there are just 4 countries where a consistent generation effect comes out from a comparison of the gender wage gap across age groups (Luxembourg, the Netherlands, Spain and France). Our country-level analysis thus sheds a different light on the trend highlighted in *She Figures 2009* towards an increase in the average EU-27 gender wage gap as age rises. Although the EU-27 average gap by age group seems to illustrate the workings of a glass ceiling that women hit during their ascent in the occupational hierarchy, this is no longer generally observed when the analysis is done at a more disaggregated level.

In a third step, the public-private divide was tested. The total gender pay gap turns out slightly bigger in the private sector than in the reduced public sector (excluding public administration and defence and compulsory social security). A dampening effect of the public sector on the gender pay gap is observed in Poland, Cyprus, Belgium, Italy and Portugal and to a lesser extent also in Greece, Spain, France and Luxembourg. On the contrary, in countries such as Romania, Bulgaria, Finland, and Hungary, the inverse is found: the gender pay gap is smaller in the private than in the public sector. The gender pay gap is of equal size in both sectors in the Netherlands and Estonia.

Finally, we were interested in comparing the size of the gender pay gap between part-time and full-time staff. In most countries, the full-time gap exceeds the part-time gap. There are just 6 countries where a clear wage penalty can be associated with part-time employment: Luxembourg, France, Belgium, the UK, Finland and the Netherlands. Although there seems to be a relationship between the gender imbalance in part-time employment and the size of the part-time wage penalty, there are 5 countries where this finding is invalidated. Indeed, Germany, Spain, Sweden, Norway and Estonia are also marked by a large gender balance in part-time employment but still the gender pay gap amongst full-timers is much larger than amongst part-timers.

O'Dorchai, S. 2010, 'The gender pay gap in research: a comparison of 23 European countries', Paper presented at the conference *Beyond the leaky pipeline. Challenges for research on gender and science*, Brussels, 19th-20th October 2010.

Research funding

The report by Meulders et al. (2010b) on pay and funding stresses the diversity of national research landscapes in Europe. This variation concerns many aspects: the overall size of the research sector; the relative research intensity measured by R&D investment; the

proportion of researchers in the total labour force; the relative size of government budget allocations to R&D; the relative size of different research sectors; the degree of centralisation and governance of funding systems; the organisation and funding of research careers (e.g. tenure); and the role and proportion of competitive research

funding in research careers. The funding situation in a country is to a great extent linked to research policies at the national, sub-national and/or European levels.

In spite of this diversity, some common trends can be found as regards gender differences in access to research funding. The report *The Gender Challenge in Research Funding* (EC, 2009b) puts forth some important results and conclusions. First, while in many cases the success rates in funding are regularly monitored and published, the gender of the applicants and awardees is not followed up and either the success rates by gender are not calculated or this information is not published. Second, all-male boards, committees and evaluation panels still exist in many countries and this is the case even in countries where the proportion of women in research is high. This may influence orientation and priorities in research as well as the gender equality policies of the funding organisations. This lack of women in gatekeeping positions gives the image of an organisation that is unwelcoming to women. Furthermore, 'the absence or heavy underrepresentation of women among evaluators and decision-makers means that women researchers are offered fewer opportunities to gain valuable understanding of the research funding system, seen from the inside, which undoubtedly would promote their own success' (p. 70). Third, the evaluation is generally based on criteria of the scientific quality of the researchers and the project, pertinence criteria with regard to the funding scheme and often on other national and social relevance criteria. However, the

recruitment of peer reviewers often remains opaque and gender is only rarely mentioned among the criteria of evaluation. A fourth and important conclusion is that based on the available data, one cannot conclude that women's success rates are systematically lower than men's. Concerning the application rate, the proportion of women applicants is lower than the proportion of potential applicants in practically all funding systems and most disciplines. The report also highlights that little research exists on application behaviour in general and especially on its gender patterns. Finally, important gender imbalances are observed among the awardees of highly prestigious grants, positions or prizes in many countries.

The meta-analysis of the literature carried out by Meulders et al. (2010b) confirms these tendencies. Overall, the studies show that:

- Women apply at a lower rate than men; success rates are not systematically lower for women than for men.
- The gender gap in applications for funding and in access to funding varies across disciplines.
- In general, it is harder for women to obtain high prestige awards. Access to a long term position is also more difficult for women than for men. Female applicants have a higher success rate when they apply for small amounts of money than when they apply for huge research grants. Finally, the higher the applicant's position in the hierarchy, the more difficult access to funding is.

Box 5. Gate-keeping, gender equality and scientific excellence

Gate-keepers and gate-keeping are a hitherto neglected but pivotal topic in studies of gendered patterns of science and academia. Gate-keepers are undoubtedly in a key position to influence the definition, evaluation and development of scientific excellence.

More generally, gate-keeping processes can control or influence the entry or access to a particular arena, the allocation of resources and information flows, the setting of standards, the development of the field and the scientific agenda, or still the external image of the arena. Gate-keeping can function as a means to exclude and control, on the one hand, but, on the other hand, it can also facilitate and provide opportunities and resources. Women are particularly underrepresented among academic gate-keepers and in leading positions in science and science policy organisations. According to the ETAN Report (2000), the gate-keepers of research funding in Europe are to a large extent constituted by middle-aged male academics. Such male domination also applies to countries such as Finland, despite the fact that the proportion of women among professors in Finland is the highest in the EU (21% in 2002). Finnish National Research Councils are, however, approaching gender parity, having had to follow the quota paragraph of the Gender Equality Act since 1995. Despite this, only 16% of the referees the Research Councils used in their funding decisions were women in 1999, as were only 14% of the board members of the largest Finnish research funding foundation. The paper presents ongoing research focusing on gender and gate-keeping in academia in relation to one key academic arena: research funding, which is analysed by studying both organisational and individual gate-keepers and their policies and practices. Gate-keepers refer here both to fund-awarding organisations as collective gate-keepers of research funding and to individuals who are involved in the decision-making bodies of such key fund-awarding organisations.

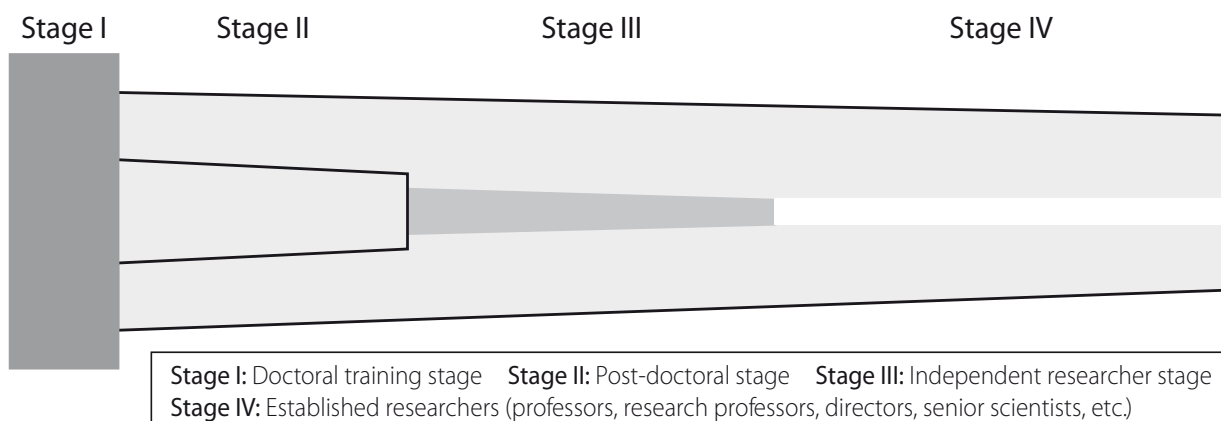
Husu, L. 2004, 'Gate-keeping, gender equality and scientific excellence' in E. Addis & M. Brouns, eds. *Gender and Excellence in the Making*, Office for Official Publications of the European Communities, Luxembourg, pp. 69-76.

Academic and non academic careers

Although scientific careers differ greatly between disciplines, institutions and national

systems, the following figure shows what can be regarded as the basic structure of the scientific career path. It is structured in four stages and only the central section represents

Figure 7. Schematic presentation of a four-stage research career



Source: ESF (2009, p. 17).

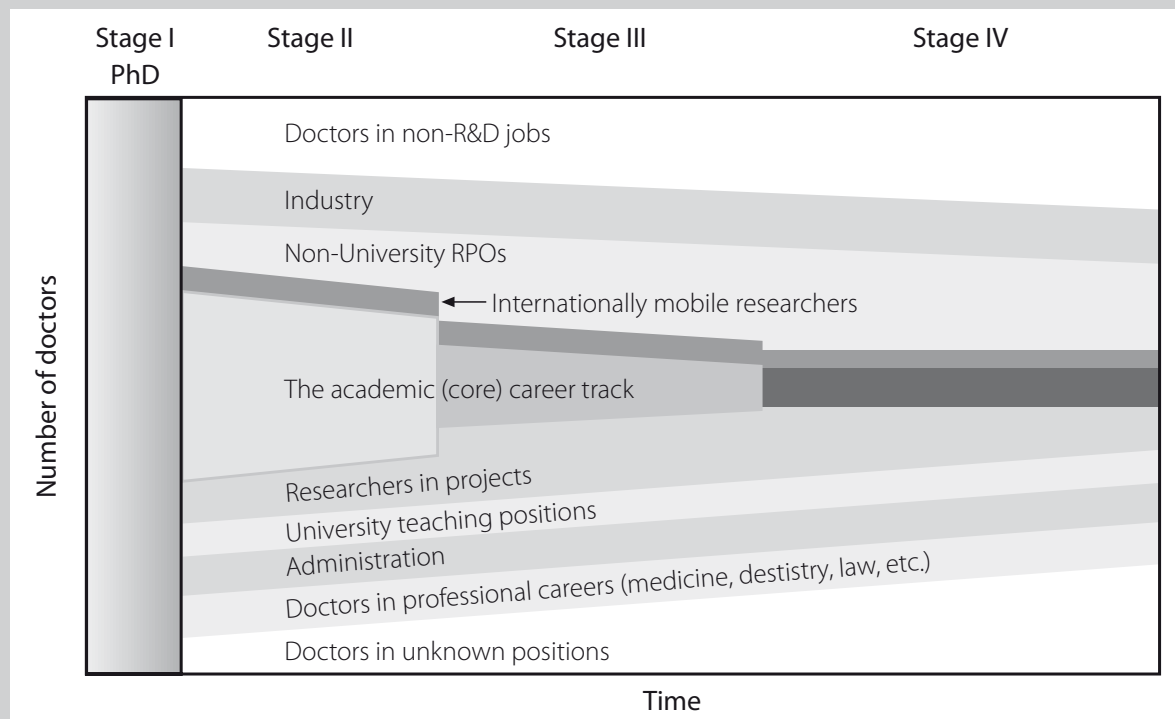
the 'excellent' academic career path, with a linear progression from the PhD to the senior scientist position.

It seems clear that a majority of PhD holders follow non-academic research careers and other professional paths, although the distribution of doctoral-level researchers in the different career paths is likely to vary across countries. Yet, 'throughout the research career, current focus is on excellence (typically

defined as the top 5-20% of applicants), while the rest of those who have entered the research career receive very little attention' (ESF, 2009, p. 28). This fact also has gender implications. More women than men leave the excellent academic career path and thus there is also a larger proportion of women who follow other paths in universities, research institutes, industrial R&D, or other science and technology-related professions. Although research on gender segregation in science

Box 6. Schematic illustration of the diversity of research careers in the European Research Area using Finland as a concrete example

The European Science Foundation report *Research Careers in Europe* (ESF, 2009, p. 18) made an attempt to quantify the proportion of PhDs that follow an academic career in Finland on the basis of official statistics and different surveys. Finnish universities annually award a total of approximately 1,500 doctoral degrees. As the number of professors appointed annually is approximately 150, roughly 10% of the newly appointed PhD holders can expect to attain a professorship.



ESF 2009, *Research Careers in Europe. Landscape and Horizons*, IREG, Strasbourg.

focuses on academia, this report considers the scientific career in its broader context and intends to review the literature that explores the situation of women who do not follow the normative academic career path.

Beyond the leaky pipeline

Ever since Berryman (1983) introduced the metaphor of the 'leaky pipeline', this conceptual approach has dominated the scientific literature on women in science. According to this perspective, the process of becoming a scientist can be conceptualised as a 'pipeline'. The science pipeline refers to the normative sequence of educational and employment stages that typically comprise a scientific career. From this point of view, the decreasing proportion of women moving up the educational/professional hierarchy is attributable to women's higher rates of attrition from the science pipeline: at each moment of transition from one educational/professional stage to another, the pipeline loses more women than men.

The meta-analysis of the literature shows the need to overcome the shortcomings of the 'leaky pipeline' approach in both research and policymaking (Langberg, 2006; Xie & Shauman, 2003). This metaphor bears witness to the fact that women are more severely underrepresented as they climb higher up the career ladder and has significantly enhanced empirical research on gender disparities across the whole process of becoming a scientist. However, it is misleading because it suggests an overly linear approach to the career path that does not take into consideration the many possible interruptions and re-entries. Furthermore, it wrongly suggests that all scientists advance at an equal pace, and that policy should focus on measures to patch up the leaks without considering the institutional constraints and subtle discrimination which women and other groups may experience in career advancement. Overall, it neither covers the complexity of the educational, professional and vital processes involved in being a scientist, nor those trajectories that move away from the normative linear career in academia.

Box 7. Leaky pipeline?

Langberg (2006) shows that the percentage of women among full professors at Danish universities increased from roughly 3% in 1976 to slightly more than 10% in 2003. Whilst the data show persistent vertical segregation, she criticizes the application of the pipeline metaphor to the Danish case: 'an investigation based on individual information showed that the idea of a 'pipeline' is misleading: among the persons that started as associate professors in Denmark only 1/3 came from positions as assistant professors at Danish universities –the rest came from positions outside the Danish university sector. Among the findings were that a large group were internationally mobile: 26 percent were not Danish citizens and 19 percent had left Denmark after their period as assistant professor/post.doc. This investigation was followed by a survey that showed that less than 60 percent of the assistant professors stayed in the Danish university sector –among these 27 percent were still assistant professors. Politics based on the pipeline-metaphor in a system like the Danish might therefore not work or even work in the wrong direction' (p. 16).

Langberg, K., 2006, 'Gender-gap and pipeline-metaphor in the public research sector', Paper prepared for the OECD *International Workshop on Women in Scientific Careers*, November 2005.

1.2 Research on gender segregation in science

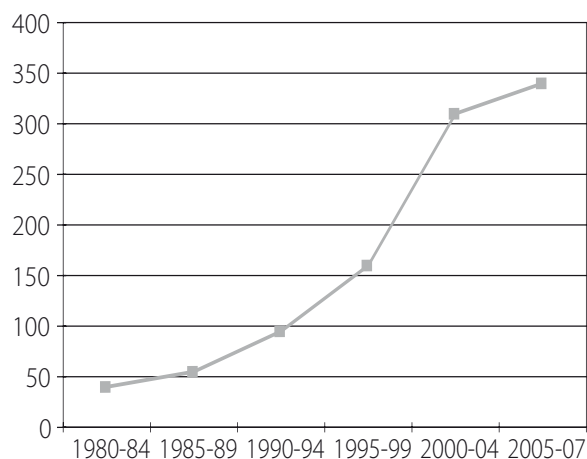
This chapter provides a general overview of trends in research, on the basis of the statistical analysis of the GSD and the reports prepared within the framework of the study. The GSD allows publications to be classified under different thematic and methodological criteria, including the main topics addressed; the institutional sectors, scientific fields and life-course stages analysed, the geographical and time coverage, the methodological approach and the kind of quantitative and qualitative techniques used. The main results of the statistical analysis of the GSD entries are presented and contextualised with the national and thematic reports.

Research on gender segregation in science has developed in close relationship to political debates and initiatives to foster women's advancement in science. While policy concern has gradually moved from women's recruitment to retention and career advancement, research has shifted from socialisation to organisational approaches, paying special attention to vertical segregation. The UK and Germany are the countries with the largest number of publications and both offer a rich strand of empirical research on gender and science issues from an organisational approach. Comparative research (across countries, scientific fields and institutional sectors) is scarce. Overall, research focuses on academia and reflects the lack of systematic sex-disaggregated data on scientists and the difficulties involved in collecting professional and personal information.

Conceptual trends

The GSD includes a total of 4,549 publications on gender and science. As shown in figure 8,

Figure 8. Average number of publications per year



Source: GSD.

GSD publications have experienced a sharp increase as of the second half of the 1990s. This increased interest in gender and science runs parallel to the increasing number of policy initiatives undertaken by the European Union and some European countries at that time.

According to the experts' reports, research on gender segregation in science has developed in close relationship to the political debates and initiatives to foster women's advancement in science (e.g. Bennet et al., 2010; Roivas, 2010; Sretenova, 2010). Policy changes have been thoroughly conceptualised by Cronin and Roger (1999) and Glover (2001) on the basis of the UK and international developments into three successive positions which loosely correspond to the three decades analysed in this report. They state that policy concern in the 1980s mainly focused on gender differences in the choice of studies and career. The reasons given for the low levels of women's scientific recruitment were based on theories of socialisation; they contended that young women were discouraged from science by deep rooted ideas about science being a 'masculine' field. Parents, teachers and peers' views contributed to forming very certain

notions of the types of jobs which were suitable for either men or women. The policy initiatives that were developed to overcome these 'barriers' were mainly intended to appeal to girls and challenge these stereotypes. Criticism towards this position emerged in the 1990s, when it was claimed that it was not enough to ask girls to change their perceptions and to 'fit in' to science: the nature of how science was taught and how jobs were organised also needed to be changed. Policy focus moved from entry and qualification issues to retention and attrition rates. In order to address women's needs and 'level the playing field', policy focus shifted gradually from individuals to institutions and organisational procedures. Special attention was paid to

work-life balance issues and equal opportunities with respect to progress in the scientific workplace alongside men, free from harassment or gender discrimination. Policy debates during the 2000s have emphasised the need to address the implicit and apparently neutral norms, values and standards of science and scientific institutions, including the epistemological basis of scientific knowledge. Schiebinger (2008b) contends that these three political approaches, although developed on a sequential basis, are currently in force and closely interrelated: increasing women's participation in science and engineering will not be successful without restructuring institutions and mainstreaming gender analysis into knowledge production (see box 8).

Box 8. Gender equality in science and technology: Three political approaches

To better understand the complex processes involved in increasing women and minorities' participation in science and technology (S&T), one can distinguish three political approaches to gender equality in these areas. The first of these approaches focuses on programs targeting women themselves in efforts to increase their participation in S&T. The second approach seeks to increase women's participation by reforming research institutions. The third focuses on overcoming gender bias by mainstreaming gender analysis into basic and applied research. These three approaches are interrelated: increasing women's participation in S&T will not be successful without restructuring institutions and mainstreaming gender analysis into knowledge production.

1. Fixing the numbers of women in science

The first and most straightforward political approach focuses on research support to increase the participation of women in S&T. The rationale is that the dearth of women scientists and engineers is a pipeline problem and that more girls and young women needed to be trained in technical fields. This first political approach seeks to increase women's participation in S&T by supporting women's educational opportunities and careers. While critically important, this approach has also been criticized for 'fixing the women': attempting to give women more education, more research money, and more training to better assimilate them to traditionally male domains. The implicit assumption is that S&T institutions and research are gender neutral. Consequently, this approach fails to look beyond women's careers to reform S&T institutions and research methods. Achieving equality requires examining gendered divisions of labour in society at large and in science specifically, as well as considering how research is conceptualized and carried out.

2. Fixing the institutions: Transforming structures and removing barriers

Despite claims to objectivity and value neutrality, academic institutions have identifiable cultures that have developed over time and, historically, in the absence of women. To the extent that Western-style science has been replicated around the world, institutional structures, cultural stereotypes, and social divisions of labour disadvantage women's participation. The second general political approach seeks to increase women's participation by reforming research institutions, implementing programs designed to create positive and permanent changes in academic, social, and scientific climates: in classrooms, laboratories, departments, institutions and organizations. Efforts in this field attempt to reform institutions that historically developed around the needs of male professionals with stay-at-home wives. Institutional reform ranges from counteracting subtle gender and ethnic biases in hiring and promotion practices to restructuring work-life balance by offering parental leave, supporting child-and elder-care, and allowing for career breaks. This second political approach focuses on restructuring institutions while assuming that what goes on inside institutions –research and knowledge production– is gender neutral. Restructuring institutions is important, but must be supplemented by efforts to eliminate gender bias from research and design. Change needs to come at a third level: gendered innovations in knowledge production.

3. Fixing the knowledge: Enhancing excellence by mainstreaming gender analysis into basic and applied research

Western science –its methods, techniques, and epistemologies– is commonly celebrated for producing objective and universal knowledge, transcending cultural restraints. With respect to gender, race, and much else, however, science is not value neutral. Research has documented how gender inequalities, built into society and research institutions, have influenced science and technology. Gender biases in research limit scientific creativity, excellence, and benefit to society. The third approach intends to enhance scientific excellence by mainstreaming gender analysis into basic and applied research.

Schiebinger, L. 2008, 'Getting More Women into Science and Engineering – Knowledge Issues' in L. Schiebinger, ed. *Gendered Innovations in Science and Engineering*, Stanford University Press, Stanford, pp. 1-21.

Our review of the literature reflects a similar shift in research, from socialisation to organisational issues, with more recent studies also addressing mainstreaming gender analysis into basic and applied research in science and technology. The initial focus was on gendered socialization –how from an early age individuals internalise 'feminine' and 'masculine' roles that shape their educational and professional choices. From this perspective, a considerable bulk of the literature on women/

gender and science addressed women's biographies and subjective experiences, their ways of building a professional identity and solving conflicts in a male-dominated environment and how they managed to reconcile their families and careers. The metaphor of the 'leaky pipeline' was understood mainly in terms of women's preferences and choices, even if socially shaped: women were said to be less professionally ambitious than men and to give priority to their family over

their career. Overall, the explanations for the underrepresentation of women in science were sought outside science and scientific institutions. Stolte-Heiskanen (1988, see box 9) provided an early account of the main gaps in this strand of the literature. On the one hand, most of the research on the problems and obstacles standing in the way of women's careers in science focused only on women as such, without any systematic comparison of men and women scientists. On the other hand, the obstacles to women's equal participation with respect to the social organisation of

science and the culture of the scientific community did not receive sufficient systematic attention. Finally, very little was known about women scientists working outside the halls of academia.

Thanks to feminism and women scientists' activism, among other things, the 1990s witnessed a gradual shift in research towards organisations and professions, their implicit norms and standards, institutional practices and power relations. In the late 1990s, attention to gender discrimination in

Box 9. Research on gender and science: only women, only academia?

This review of the problems of women's careers in science 1) focuses on the reasons why the position of women in science is an important issue, 2) reviews the state of the art of research in this field and 3) indicates the major problems and gaps in our present knowledge, and outlines some directions future research may profitably explore. A comparative perspective is needed to overcome potential gender biases. Most of the empirical research on the problems and obstacles of women's careers in science focuses only on women as such, and the problems revealed are assumed to be particularly those relating to women scientists. From a methodological point of view, the validity of the generalisations concerning women scientists must rest on the demonstration that they are gender specific. This implies that there is the need for systematic comparisons of men and women scientists. A review of the literature shows that most research on women's careers in science concentrates on academic women. However, in the contemporary world of science and technology, a considerably greater share of research and development activities is done outside the universities. Yet, there is very little information about women scientists working outside the halls of academia, in independent public or private research institutions or in the research institutes and laboratories of the productive sector. The obstacles presented by the social organisation of science and the culture of the scientific community with respect to women's equal participation have not received sufficient systematic attention. Only by focusing on how these social processes of the scientific community affect women scientists will we be able to identify the problems faced by professional women that are specifically associated with being a scientist. The extent to which women scientists are represented in the scientific establishment participating in advisory and decision-making bodies is also a hitherto neglected research area.

Stolte-Heiskanen, V. 1988, *Women's participation in positions of responsibility in careers of science and technology: obstacles and opportunities*, Tampereen yliopiston sosiologian ja sosiaalipsykologian laitoksen työraportteja, sarja B 26/1988. Tampereen yliopisto, Tampere.

academia was indeed fostered by two major 'scandals': the article by Wennerås and Wold (1997), which found evidence of sexism and nepotism in the peer-review system in Sweden, and the report by the Massachusetts Institute of Technology (MIT), which admitted publicly having given less pay and resources to female than to male scientists of equal seniority (MIT, 1999). Research put the emphasis on overt and covert discrimination against women, attempting to unveil the hidden mechanisms of male domination in scientific institutions (Bagilhole & Goode, 2001; Kraus, 2000). The ETAN report (Osborn et al., 2000) made a plea to overcome patronage and the 'old boys' network' in European academic institutions and implement more transparent and fairer recruitment and assessment procedures.

Recent studies address the progressive differentiation of men and women's careers through both supply-side and demand-side factors. The overall impression is that there is no single-factor explanation for gender segregation in science. It has the same root causes as gender segregation in the labour market as a whole, although it is acknowledged that mainstream research has largely neglected the demand-side or organisational factors (Bettio & Verashchagina, 2009). The life course perspective puts the emphasis on the interaction between the institutional level and the individual level. As Xie and Shauman (2003) argue, this approach contends that gender inequalities in the scientific career can be explained by the interaction of structural allocation and self-selection processes. It attempts to grasp the complexity of human life, with multiple trajectories in education, family and work, in which developments in the professional trajectory are accompanied, and possibly influenced, by developments in other areas. Some recent studies also pay increased attention to cultural and institutional diversity within science itself, especially in terms of national contexts, claiming that it is necessary to analyse more fully the mechanisms

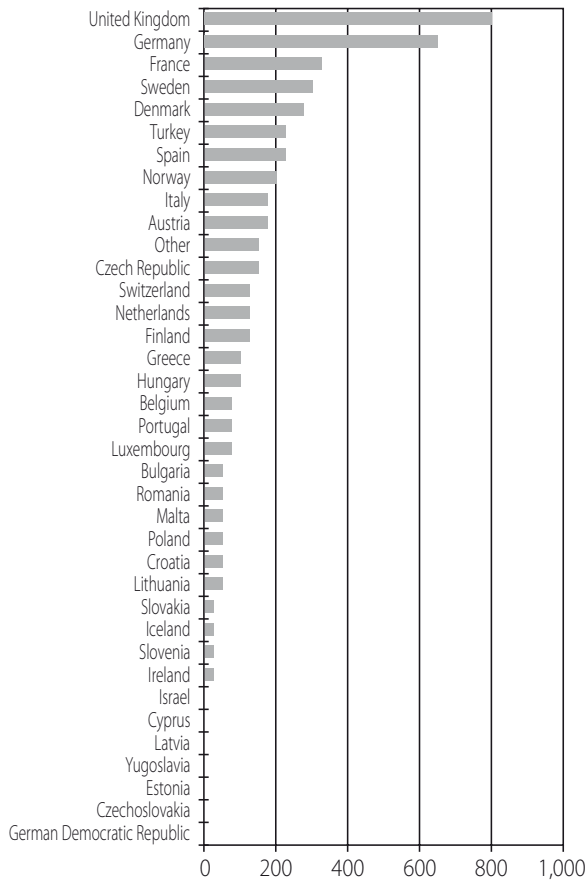
that underpin the feminisation process in specific national and professional contexts (Le Feuvre, 2009). On the other hand, recent studies show a wider scope of research, with increasing attention to gender and non-academic careers (Etzkowitz et al., 2009; Meulders et al., 2003; Smith-Doerr, 2004). Finally, a new wave of studies addresses the epistemological and methodological basis for mainstreaming gender analysis in life sciences and engineering (Klinge, 2008; Schiebinger, 2008a).

Obviously, research at the national or local level presents a large degree of variation set against this general pattern. In some countries research on gender segregation in scientific careers is just starting or focuses mainly on women's 'deficits' and 'barriers'. Although relevant studies can be found in all the countries analysed, empirical research from an organisational approach appears to be more established in the Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Sweden and the UK.

Geographical trends

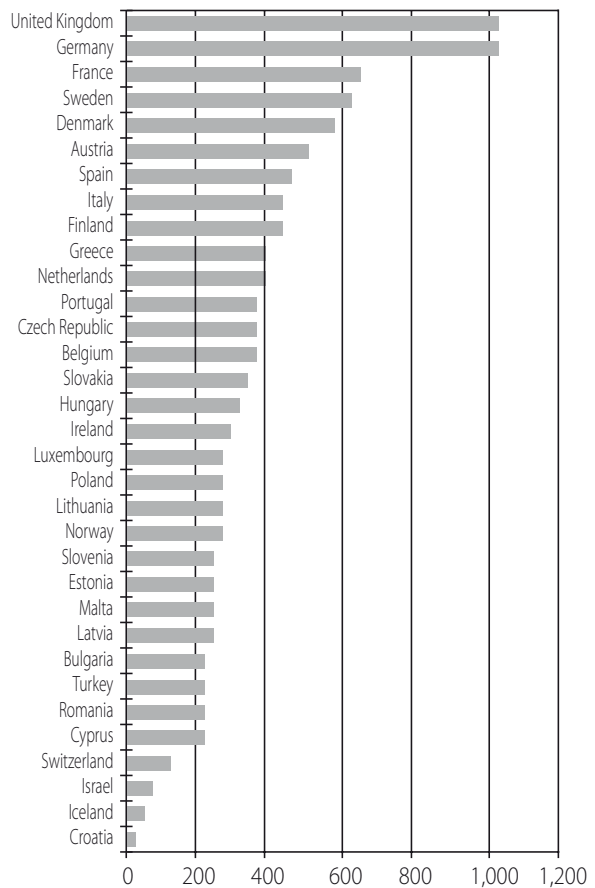
The figures above show the distribution of GSD publications in geographical terms. Figure 9 looks at the country in which the study was published, whilst Figure 10 shows the country or countries the study analysed. In both cases, two countries stand out clearly: most of the publications have been published either in the UK or Germany and analyse the situation in these countries. The number of publications is at best a very rough indicator of the attention paid to gender and science issues at the national level. Any cross-national comparison should take into account that size matters (in terms of population, scientific community, etc) and acknowledge the increasing tendency towards publishing in international journals, which gives advantage to English-speaking

Figure 9. Publications by country of publication



Source: GSD.

Figure 10. Publications by country analysed



Source: GSD.

journals. However, it remains true that in accordance with our review of the literature, very little has been published about the situation in some European countries whilst there appears to be a large bulk of research dealing with the UK and Germany (Bennet et al., 2010; Diallo et al., 2010).

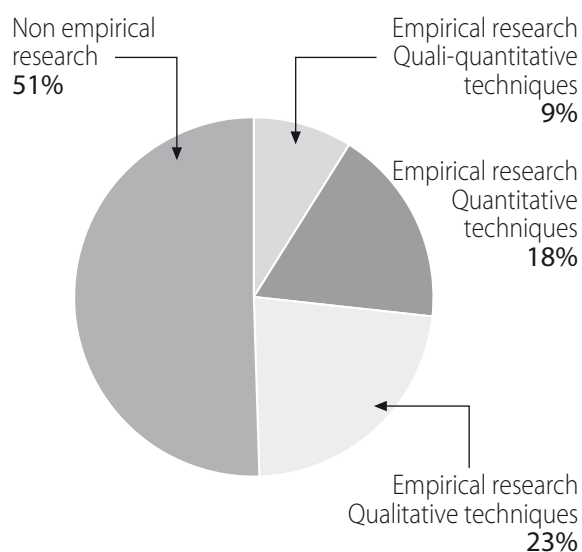
The analysis of the GSD confirms that most of the literature on gender and science is developed at the national level, with only a small percentage of comparative studies. Of all the GSD publications, the large majority (81%) analyse the situation in one single country whilst many of the studies dealing with several countries focus on the compilation of statistics or address very general issues.

Although it is not possible to provide a precise figure, it seems clear that truly comparative research on gender differences in scientific careers is very scarce. Studies rarely compare different countries and there are almost no synthetic reports offering a state-of-the-art on the situation of women in science and research throughout Europe. There is also a lack of comprehensive evaluations and critical reviews of the available research. Furthermore, even if research on the subject of segregation in scientific fields has been carried out in all countries, there is a lack of comparability of results due to variations in coverage: different time frames, different disciplines, samples, etc. More unified, homogeneous and systematic research for

all European countries is needed to overcome this persisting fragmentation of research.

Methodological trends

Figure 11. Percentage of publications by methodological approach



Source: GSD.

Table 6. Percentage of publications by technique

Quantitative techniques	%
Representative sample	57.0
Micro-data	48.6
Multivariate analysis	30.8
Longitudinal/cohort	8.2
Qualitative techniques	%
Interviews	64.8
Biographical research	17.6
Case studies	15.4
Content analysis	15.4
Observations	15.2

Figure 11 illustrates the methodological approach of GSD publications. It shows clearly that a large share of the studies (51%) are not based on empirical research: they are basically state-of-the-art studies, which compile some basic data and provide an overview of international literature and debates, usually meant to foster awareness and draw recommendations for policymaking at the national or institutional level. Empirical research is split into qualitative (23%) and quantitative studies (18%), with only a small percentage (9%) of publications combining quantitative and qualitative empirical techniques.

Table 6 provides further details about the kind of empirical techniques used. Most of the qualitative studies are based on interviews (65%), whilst only 8% of the quantitative studies are based on longitudinal/cohort data and only 31% carry out multivariable analyses. Overall, these trends confirm what most national reports state: In general, descriptive research prevails and the majority of publications are based on small-scale studies, mostly based on the compilation of cross-sectional data or interviews focusing on the experiences and perceptions of female scientists at one or two institutions.

The systematic comparison of men and women scientists is a trend apparent in more recent studies, which usually adopt an organisational approach. However, the literature reflects the lack of systematic sex-disaggregated data on scientists as well as the difficulties involved in collecting personal and family information, particularly salient in some European countries. This is a significant hindrance for research, which would need more systematic data on sociodemographic variables and career advancement to develop more consistent lines of research, on the basis of both quantitative and qualitative approaches. Moreover, only rarely do studies adopt a life course perspective: the great

Box 10. A longitudinal approach to gender segregation

Comprehensive research on the Italian case was carried out by Palomba (2000). According to the author, the measurement of vertical segregation is the most suitable for addressing the issue of inequality between the sexes and measuring the lack of recognition of talented women. A mere description of the present situation of progressively fewer women in the higher echelons is not sufficient to demonstrate the existence of vertical segregation in scientific research. To evaluate vertical segregation properly, it is necessary to have information on the career paths of men and women from the time they started working for an organisation, university or research institution. Specific measurements should be made to demonstrate inequalities among people who started under the same conditions. Examples are the survival curves for each professional position and the amount of time spent. The place where research is being conducted should also be taken into consideration. Some bodies or institutes are more prestigious whereas other organisations might receive scant attention from the academic and scientific world. The presence of women in these more prestigious institutions should be measured as it is probably more difficult for them to work insofar as there is more male competition.

Both horizontal and vertical segregation should be viewed in the light of gender differences in salaries and research-project funding. Gender and economic inequality are obviously linked but the relation to gender segregation is not yet clear. The key point is that professional position determines prestige in the scientific community. Prestige leads to more invitations to important conferences, to being quoted in colleagues' work and to receiving research funding, all crucial in getting published, which is an important appraisal criterion when it comes to career advancement.

Palomba, R. (ed.) 2000, *Figlie di Minerva*, Franco Angeli, Milano.

majority of them illustrate the problem of segregation at a particular moment in time –one stage of the life course. However, a life course approach would potentially be very useful to improve our understanding of the gendered patterns of cumulative advantages and disadvantages in scientific careers, as shown by the few studies that do manage to build on this longitudinal approach (e.g.; Abele et al., 2004; Blackwell & Glover, 2008; Palomba, 2000, among others).

Thematic trends

Table 7 summarises the main trends of the literature with regard to thematic issues.

Many publications do not strictly focus on one specific topic, but are multi-topic studies that generally deal with women's situation in science and address a large variety of issues. In general, the analysis of vertical segregation is mostly related to the topic of science as a labour activity, whilst horizontal segregation is addressed through the lens of stereotypes and identity. The most underresearched themes are scientific excellence (20%), pay (8%) and research funding (6%). In spite of the large number of entries dealing with the topic of gender equality policies (28%), policy evaluation is also a largely neglected issue according to the expert's reports.

Table 7. Percentage of publications by thematic issues

Topic analysed	%
Horizontal segregation	43.2
Vertical segregation	44.7
Pay	7.8
Funding	6.3
Stereotypes and identity	54.0
Science as a labour activity	32.6
Scientific excellence	19.8
Gender in research contents	31.5
Policies towards gender equality in research	28.5
Period analysed	%
General / Not specified	4.5
Before the 18th century	1.4
18th century	1.4
19th century	5.0
1900-1945	10.1
1946-1970	13.6
1970s	19.5
1980s	33.0
1990s	49.5
2000s / Present-day	46.4
Institutional sector	%
All/General	48.8
Other	51.2
Total	100.0
Institutional sector - Other	%
Business enterprise sector	10.6
Government sector	26.0
Higher education sector	86.7
Private non-profit sector	3.4
Scientific field	%
All/General	38.7
Other	61.3
Total	100.0
Scientific field - Other	%
Education	20.6
Humanities and arts	18.3
Science, mathematics and computing	46.6
Agriculture and veterinary	8.5
Health and social services	21.9
Engineering, manufacturing and construction	25.1
Social sciences, business and law	34.1
Services	0.7
Specific scientific discipline	%
No	72.8
Yes	27.2
Total	100.0
Life course stage	%
All/General	23.8
Other	76.2
Total	100.0
Life course stage - Other	%
ISCED 0	2.0
ISCED 1	6.8
ISCED 2	11.0
ISCED 3	13.8
ISCED 4	6.4
ISCED 5	36.2
ISCED 6	38.4
Early-career scientists	67.6
Mid-career scientists	62.8
Late-career scientists	59.4
Other	6.5

Source: GSD.

Most of the entries refer to the 1990s and 2000s, with just one third of the entries dealing with the 1980s and one fifth with the 1970s. There is, however, a significant strand of the literature that takes a historical approach, analysing the history of women's admission to university studies and the lives of women pioneers in academia and scientific professions (see Addis, 2010 and Palasik et al., 2010).

The analysis of the institutional sector differentiates between entries that do not address any sector in particular and the remainder, which do. We can see that a large proportion of entries deal with science in general, paying no specific attention to diversity across institutional sectors (49%). Furthermore, most of the entries addressing this issue are concerned with the higher education sector (87%). Overall, this data confirms that a large bulk of the literature focuses on academia, with little research on industrial R&D. This is also a reflection of the fact that a substantial amount of literature on highly-skilled professions such as medicine, engineering or ICT was not included in the GSD because no explicit reference was made to research.

Trends are similar as regards the scientific field analysed. A large number of studies address science in general, without specifying any particular discipline (39%). The analysis also confirms that a high percentage of studies dealing with specific disciplines focus on the natural sciences, mathematics and computing, that is 'science' in the strictest sense (47%). According to the national reports, the professions most widely analysed are the most traditionally male-dominated, although more recent studies are paying special attention to fields like medicine or biology in which the proportion of women has increased rapidly. In some countries, notably the UK, the literature on gender and science only rarely includes social scientists. Finally, it is also worth noting that studies focus generally on

researchers and do not include technicians or research support staff.

Finally, GSD entries are also classified according to the life-course stage analysed. In this case, we can see that most of the entries address some specific stages (76%), the early stage being the most widely researched (68%). This trend is confirmed by most of the national reports, which highlight that research on gender and science pays special attention to young researchers, specifically in terms of career and family conflict, working conditions and attrition rates.

Gaps and key issues

Overall, the meta-analysis of the literature provides a clear overview of the most under-researched themes as regards gender and science:

- Non-normative scientific careers is a largely neglected topic. In general, studies concentrate on academia and focus on scientists that pursue the most standard path. Little is known about those scientists who leave the academic pipeline or fail to adjust to the rigidity of the academic 'tempo'. Industrial research and other science and technology-related professions remain under-researched (Caprile & Vallès, 2010).
- There is a lack of theoretical and empirical research on the criteria and procedures for assessing scientific excellence (Addis, 2010). Particularly, studies about research funding are noticeably absent (Meulders et al., 2010b), specifically analysis of the recruitment practices for gate-keeping positions, as well as of the practices of the different bodies and scientific committees that award research grants and funds and assess scientific excellence. Overall, the lack of transparency in awarding procedures hinders empirical research.

- Research on pay in scientific professions is scarce. It is a rather new topic of study, for three reasons (Meulders et al., 2010b): First, there is a lack of available official data on income and gender income differences. Second, in an important number of research institutions wages are entirely determined by rank and seniority. Third, in some countries and in some cultures, discussions of earnings are taboo (e.g. Cheveigné & Muscinési, 2009 for France or Palasik, 2009 for Hungary).
- Research addressing the evaluation of gender equality policies in science and research is scarce. With regard to the literature on gender equality policies, an unequal distribution of the research literature can be seen. There is a relative abundance of position statements, conceptual clarifications and recommendations dealing with gender issues in science and research across most participating countries. There is also a relatively large body of research documenting policy attempts to eliminate the vertical and horizontal segregation of women in relation to men in science and research. However, there are comparatively fewer systematic evaluations of policy measures (Castaño et al., 2010).

The meta-analysis of the literature also shows a number of key issues for research and policymaking, which will be addressed in the next chapters. Three of them refer to gender differences in scientific careers and are presented in the second part of this report:

- Choice of studies. In order to explain the persistence of horizontal segregation in education, research shows the relevance of structural/life-course factors and addresses the patterns of continuity and change in gender stereotypes.
- The 'rush hour'. Research in this field addresses the family related time and

mobility constraints that disproportionately affect women in the context of the gender division of labour. Studies show that the so-called 'work-life' conflict is not only gendered, but is actually exacerbated by scientific institutions. Family and career tensions help to explain why fewer women than men engage in a scientific career and more women than men leave academia at the early stage of the scientific career. However, it cannot fully account for vertical segregation.

- Career advancement. To address vertical segregation in science, research goes beyond the formal meritocratic rules, analysing recruitment, promotion and recognition through the lens of power relations, gate-keeping practices and informal networks. Subtle discrimination and cumulative advantages and disadvantages in career advancement are analysed, also with respect to the issue of excellence.

Another strand of research focuses on the analysis of gender, scientific institutions and scientific knowledge and is presented in the third part of the report:

- Institutional change and its ambivalent impact on gender equality, both in academic and non-academic settings: the restructuring of universities under new managerial criteria; the erosion of the hierarchy and individual competition in certain university departments and R&D firms; the development of science and technology-related professions and, finally, the sociopolitical changes in Eastern countries and their impact on gender relations and scientific careers.
- Gender dimension in research content. A growing body of literature shows that gender biases in research limit scientific creativity, excellence, and benefits to society. Gender theory has had an enormous impact in the humanities and social sciences over the

past thirty years and is increasingly being integrated into medicine and the life sciences, although it is less developed in engineering and technology. Current approaches focus on gender as a resource for enhancing scientific excellence in basic and applied research.

- Policies towards gender equality in science and research and its weak impact on institutions and scientific culture. The current approach towards gender equality

in science involves not only supporting women, but reforming scientific institutions and overcoming gender biases in knowledge production. It also involves a different sequence of measures in order to achieve gender goals. At present, the main challenge is not to define new policies but to reinforce their effects through in depth evaluation and transferability. It implies developing sound theoretical frameworks, appropriate methodological tools and shared evaluation standards.

2

SCIENTIFIC CAREERS

2.1 Choice of studies

Gender segregation in education is widely acknowledged as one of the roots of gender segregation in science. In spite of de-segregation trends over the last decades, study field choices remain largely gendered. The absence of a mixed gender composition in the different fields of study can already be observed in secondary education, and is in turn reflected in higher education. The interplay of many individual, institutional, social and cultural mechanisms across different levels has been used to analyse horizontal gender segregation in fields of study and related professional paths. After decades of research it seems clear that there is no single-factor explanation for gender segregation in education. In this chapter we review this strand of the literature, on the basis of the reports on segregation (Meulders et al., 2010a) and stereotypes (Sagebiel & Vázquez-Cupeiro, 2010).

Research on gender segregation in education has been extensive although many studies point to two important conceptual problems. First, gender segregation in education is almost always presented from the perspective of the educational choices made by girls, even though gender segregation is also due to boys' preferences for certain fields of study. If the aim is to change these trends and introduce more of a gender balance in all study fields, then it is with respect to the entire set of factors upstream of the study field choices that genuine theoretical and political questioning should take place; while doing so, equal attention should be given to both girls' and boys' choices. Working towards a more mixed composition of all study fields should not mean an alignment to the male model (Meulders et al., 2010a; Sagebiel & Vázquez-Cupeiro, 2010).

Second, a substantial strand of the literature is still based on the assumption that the

underachievement of girls compared to boys in maths is the main reason for gender imbalance in university studies. Therefore, research has paid special attention to explaining the gender gap in maths achievement, with a longstanding debate between inborn and learned sex differences in cognitive abilities. On the whole, these studies fail to acknowledge that 1) differences in maths achievement are narrowing or have disappeared (and little attention is paid to persistent large differences in reading literacy favourable to girls) and 2) achievement in maths at school is not a good predictor of choice of study field at university (talented girls make more diverse choices than equally talented boys) (Alaluf et al., 2003a, Xie & Shauman, 2003).

Recent studies show that structural and life-course factors play a major role, both in terms of educational achievement and study field choices. Differences are less pronounced in integrated educational systems and in more gender-equal societies. On the other hand, research shows that 'choice' should be used with caution – people live purposeful lives, but socialisation actors – family, school, peers, the media – play a major role. Social norms and parental expectations are important determinants of segregation that are not always covered in the literature analysed. Furthermore, studies tend to focus on the persistence of gender stereotypes, but the fact that they are historically constructed and permeable to change remains a largely under-researched issue.

Old explanations

In an effort to explain gender-differential success in science and technology, a certain branch of research focuses on inborn cognitive sex differences and their influence on educational achievement and educational and professional choices. On the basis of

measured sex differences in mathematical and spatial performance and in verbal and written abilities, a large bulk of studies, mostly in the Anglo-Saxon literature, have focused on brain structure and function, hormonal influence on cognitive performance, psychological development in infancy and evolutionary psychology to suggest a biological basis for the differing career outcomes of women and men (NAS, 2007). Although it is a recurrent debate, this strand of the literature does not show any empirical evidence that sex differences in cognitive, neurological and biological endowment (often small and in many cases nonexistent) may account for gender differences in scientific careers (NAS, 2007). On the contrary, it shows that there is an interplay of psychosocial and sociocultural factors (Halpern & Tan, 2001).

Since the 1970s there has been a large body of research devoted to the measurement and explanation of gender differences in mathematical aptitude, ability and achievement (Geary, 1996; Huttenlocher et al., 1998; Pinker, 2002; Shepard & Metzler, 1971; Spelke, 2005) due to the crucial role that this subject plays in success in careers in science and engineering and because traditionally girls have scored worse than boys in maths tests. In spite of the inherent meaningfulness of this strand of research, in most cases the underlying assumption is that girls' underachievement in maths is the main cause of the underrepresentation of women in scientific and technological studies, a fact which has not been confirmed by recent studies (Alaluf et al., 2003a; Xie & Shauman, 2003).

Structural and life-course factors

Cross-national studies reveal that girls' underachievement in maths has narrowed in all countries and is on the way to disappearing in most of them (Else-Quest et al., 2010;

Epstein et al., 1998; Sapienza, 2008). According to the latest PISA results, in some countries (Sweden, Norway and Iceland) girls score as high as or higher than boys in mathematics. In this regard, recent comparative research shows that more attention to structural factors should be paid. The type of educational systems and the development of gender equality in society are seen to be important explanatory factors for both maths achievement and study choices.

Guiso et al. (2009) analysed differences in maths test performances across 40 countries using PISA data and its relation to cultural and structural inputs. Girls' math scores were on average 10.5 points lower than boys', but the results vary by country. The gender gap was reversed in reading: girls have reading scores that were on average 32.7 points higher than those of boys. To explore the cultural inputs affecting these results, countries were classified according to several measures of gender equality (World Economic Forum's [WEF] Gender Gap Index [GGI]; World Values Survey for reconstructing cultural attitudes; female economic activity; and WEF's measures of women's political empowerment). The authors found a positive correlation between gender inequality and the gender gap in mathematics. Overall, the results suggest that the gender gap in maths, although historically in favour of boys, disappears in more gender-equal societies. On the contrary, the gender gap in reading that is in favour of girls and apparent in all countries is greater in more gender-equal societies. In countries with a higher GGI index, girls close the gender gap by becoming better at both maths and reading. In more gender-equal societies, girls perform as well as boys in maths and much better than them in reading.

Van Langen et al. (2006) analysed the variation in gender gaps in mathematics, science, and reading literacy, both across countries and across schools within countries, using the PISA

data. They showed that 'integrated educational systems tend to generally be more favourable to the achievement of girls relative to boys than differentiated educational systems. Stated differently, the more differentiated the educational system, the larger the mathematics and science arrears of girls relative to boys and the smaller the reading arrears of boys relative to girls. A more useful starting point to increase the proportion of women in sciences may be the degree of integration/differentiation which characterizes a country's educational system' (p. 174). The degree of integration/differentiation of the educational system also has consequences from a life-course perspective: more differentiated and rigid systems lead to study choices during adolescence that determine university and professional paths. This fact

reinforces gender segregation in education, as adolescence tends to exacerbate traditionally gendered choices. As Bennet et al. (2010) state, age and its importance in attitude formation is implicit in many studies but very few have looked at the way young people's experience of the world as they mature alters their perceptions of gendered stereotypes in science. Francis (2002) found little understanding of the nature of the adult labour market among a 14-16 cohort of girls and boys whose gendered aspirations were at odds with the reality of contemporary jobs. Evidence collected in schools in the 1990s has shown clearly that negative attitudes towards science education form at a particular point in secondary school studies. During the first three years, girls' and boys' attitudes towards maths and science subjects become more

Box 11. Exploring cross-national differences in gender gaps in education

'The results of multilevel analyses show the participation of women in tertiary STEM (Science, Technology, Engineering and Mathematics) education to increase as the relative achievements of girls with respect to boys in secondary education improve. When the characteristics of schools and countries are examined in relation to the size of the gender achievement gaps, integrated educational systems are found to be more favourable to the achievement of girls than differentiated educational systems. In the first part of this article, we showed the participation of women in tertiary STEM education is generally low although countries differ drastically with regard to such. Poland, Ireland, Spain, and Italy constitute positive exceptions with percentages reaching 40%. Switzerland and the Netherlands constitute negative exceptions with figures lower than 20%. The analyses presented next, using the data from PISA 2000 and PISA+ revealed a remarkable pattern. The national gender gaps for science, mathematics, and reading literacy in secondary education were found to correlate highly with each other: In countries where girls lag less behind boys in mathematics and science, they also are more ahead of boys in reading. Conversely, in countries where boys lag less behind girls in reading, they also are more ahead of girls in mathematics and science. There are countries where the mathematics literacy of girls does not lag behind that of boys at all (e.g., New Zealand, Iceland, Finland, Albania, Thailand), but –in keeping with the foregoing observation– the reading proficiency of the boys in these countries then lags considerably behind the reading proficiency of girls' (p. 172).

Van Langen, A., Bosker, R. & Dekkers, H. 2006, 'Exploring cross-national differences in gender gaps in education', *Educational Research and Evaluation*, vol. 12, no. 2, pp. 155-177.

Box 12. Access of young women to scientific and technical studies

The report examines the conditions of access of young women to university scientific and technological studies. It is also an attempt to identify the multiple elements which contribute to produce differences in the choice of studies of boys and girls. The report is based on the results of a survey carried out at the Free University of Brussels among new students. In general, two groups of elements influence the possibilities and the choices of studies: the socio-cultural characteristics in the family circle, and the school course. They crossed with these two groups of factors the personal aspirations and the professional projects. These factors have a very different impact depending on sex. The majority of boys with the option of 'strong maths' in the secondary education will generally move to scientific studies while girls with the same option will show more dispersion in the choice of studies. Several options are considered as offering good perspectives for employment but a real ignorance does exist concerning the variety and the quality of accessible jobs at the end of the university courses. This ignorance is particularly important in the choice of girls.

Alaluf, M. & Marage, P. 2002, Newtonia. *Accès des jeunes femmes aux études scientifiques et techniques*, Université Libre de Bruxelles. Downloaded on 16/11/2010, available at:

<http://newscientist.ulb.ac.be/docs/Rapport2002.pdf>

rigid, with girls showing a more pronounced decline in interest (Barnby et al., 2008). This is supported by the results of a large attitudinal study of young people aged 13-14 conducted in Wales to compare attitudes towards English and sciences (Hendley et al., 1995).

Overall, such studies do not fully account for gender differences in study field choices. As stated by Xie and Shuman (2003, p. 208) with regard to the situation in the US, 'the gender gap in average mathematics achievement is small and has been declining, although boys remain much more likely than girls to attain a high level of competence. Gender differences in neither average nor high achievement in mathematics can explain young men's greater likelihood of majoring in science and engineering fields compared to young women'. A similar conclusion is reached by Alaluf and colleagues for Belgium (Alaluf & Marage, 2002; Alaluf et al., 2003a). They contend that success in school is more a function of social origin than

of any other characteristic. Girls are currently performing better at school than boys, but their choice of studies differs. Girls tend to select less highly-regarded options or orientations. Boys who have taken the strong mathematical option at secondary school are concentrated in fields with a strong scientific component, while girls who have taken the same option are more evenly distributed across the entire range of possible fields. To account for gendered motivations and interests and to gain a better understanding of the educational choices of girls and boys, the main focus of explanatory factors need to be changed from the analysis of maths performance to gendered socialisation and its interplay with structural and life-course factors.

Socialisation factors

A broad theoretical perspective in analysing educational and professional choices is

connected with the lifelong process of socialisation and the construction of gender identity. At the heart of this approach is the idea that the dualistic notion of gender reinforces traditional gender stereotypes that associate men with technical skills and women with social skills. The dichotomy between the feminine and the masculine establishes gender stereotyping, gender roles and a gendered division of labour. In this binary way of thinking, women are responsible for reproductive and men for productive work in society.

Gender stereotypes are 'deep-rooted perceptions of male and female characteristics which support the continuity of specific gender roles and occupational segregation' (Suter, 2006, p. 98). Distinct from the rational choice and role model approaches, the perspective of the construction of gender stereotypes is more comprehensive (Xie & Shauman, 2003). This body of literature focuses on differing social pressures that have a greater influence on the motivations and preferences of boys and girls when choosing their careers than their underlying abilities do.

The construction of gender identity is not a linear process, but a contradictory and conflictive life-course process through which traditional gender roles are assimilated or transgressed and gender identity is negotiated in multiple and varied contexts. In each context emerge identity forms linked to the other contexts which interact with each other (Caprile et al., 2008a). The pressures and influences of socialisation agents in the construction of gender identity during infancy and adolescence have been widely analysed in an effort to understand how the mechanisms of gender stereotyping are reproduced and to explain different educational choices by sex (Duru-Bellat & Terrail, 1995). Family support and the recommendations of primary reference groups such as parents, teachers and friends have been identified as essential factors for

the choice of a study subject (Zwick & Renn, 2000). In this way, the role of the family, the school, peers and leisure activities has been explored in order to ascertain the influence of the main socialisation agents in the construction of gender identity and its impact on the educational choices of girls and boys.

Family influences boys' and girls' educational choices and paths through the transmission of parents' expectations and career choices. During childhood parents not only tend to encourage sex differences in behaviour and experience by treating boys and girls differently, but also by evaluating their abilities differently (Jacobs & Eccles, 1992; NAS, 2007). Social forces in the family space also affect gender differences in career choice through role modeling. Parents act as role models for their sons and daughters. The presence of someone in the family who has undertaken scientific-technical studies has a great impact on the fact that girls choose this type of studies (Hapness & Rasmussen, 2000). Research has shown that children with parents holding a PhD degree more often undertake a PhD thesis themselves (Högskoleverket 2006; Leeman, 2002).

Children living in households characterised by gender equality tend to make less gender-stereotyped classifications of occupations. Girls from such families more often want to pursue non-traditional careers (Weisner & Wilson-Mitchell, 1990). In this kind of household, girls tend to express a stronger interest in mathematics (Jacobs & Eccles, 1992; NAS, 2007), while obtaining better results in secondary school, especially in maths and science (Updegraff et al., 1996).

In the school, teacher-pupil interactions in the classroom play an important role in this respect (Ammermüller & Dolton, 2006). Teachers have stereotyped attitudes towards girls and boys in class, although they themselves are usually unaware of their gender-biased

reactions. In this way, teachers' expectations of their students become reality, as girls are often discouraged from enrolling in courses and studies that run counter to gender stereotypes. While gender bias in the interaction between the teacher and students is found in all subject areas, the greatest bias is found in maths and science classes. The 'hidden curriculum' transmits messages that often reinforce gender stereotyping and the dominance of boys regarding the school space.

Another issue analysed is the influence of the peer group during adolescence, the vital moment in which educational choices are first made. Friends and peer groups are the main reference groups for teenagers. They tend not to look favourably on technical subjects (perceived as more difficult) and associate technical abilities and interests with masculinity. This may discourage girls from undertaking technical studies, also because research shows that girls are more sensitive than boys to the perception of social acceptance (Håpnes & Rasmussen, 2000).

Leisure activities and the mass media are currently among the most powerful socialization channels and play an important part in transmitting gender roles and the culture's pervasive stereotypes. It has been shown that television and videogames perpetuate traditional gender stereotypes insofar as they reflect dominant social values (Cassell & Jenkins, 2000). Boys' games are more physical, vigorous and competitive than girls'. The characteristics of scientists as they appear in the mass media have similarly been analysed. In the media the role of the male scientist is more prevalent than that of the female scientist; male scientists show 'masculine' attributes (independence and dominance), while female scientists are portrayed with 'feminine' attributes (dependence, caring, and a romantic nature) (Steinke et al., 2008). This fact has long been acknowledged, with several initiatives aimed at challenging the gendered stereotypical images of scientists, engineers and technicians (e.g. the European project *Motivation*, in Sagebiel et al., 2009).

Box 13. Media representations of women scientists

The underrepresentation of women in the scientific community is currently on the agenda of science policy both in the Nordic countries and internationally. The significance of media as a provider of female role models, on the one hand, and in reproducing stereotypical images of scientists, on the other hand, is often mentioned in this context. However, very little research exists on media representations of women scientists and in Finland, the issue has not been studied. Finland provides an interesting context for the study of public representations of women in science, because in Finland the proportion of women scientists and female professors is among the highest in the European Union.

In this study, the media representations of women scientists in Finland were explored by analysing interviews in the Finnish print media: newspapers and magazines. The data consist of 95 interviews published in 1997–2002. An overwhelming majority of the interviews were written by female journalists. A two month follow-up of the interviews in the main newspaper suggested that male scientists are more often interviewed by male journalists and women are interviewed much less than men. Only one third of the interviews with scientists had women as interviewees. The analysis focused on both social

and linguistic aspects of the interviews. First, we explored how the journalists framed the researchers in question. These frames were classified as 'super achievers', 'multitalents', 'pioneers' or 'ordinary researchers'. Secondly, we were interested in how the interviews discussed the impact of gender on one's research career, whether female gender was presented as an obstacle, resource, or both. Thirdly, we explored how and whether issues related to the family – spouse, partner, children, parents and other relatives – were presented in the media images. Fourthly, we analysed how and with what kind of linguistic means the interviewed scientists were presented and characterized as women. We explored, for example, comments on their appearance and personality, as in the following: The first female University Chancellor Leena Kartio was characterized in the following manner in the main newspaper: 'The Chancellor starting her work next August is small and delicate. She is dressed in a well-tailored grey trouser suit' ('Ensi elokuussa työnsä aloittava kansleri on pieni ja siro. Hän on pukeutunut hyvin istuvaan harmaaseen housupukuun', HS 20.5.2000). Special attention was paid to the verbs, adjectives and other characterizations used to describe the ways the interviewees expressed themselves, for example, of professor Anni Huhtala it is said that 'She ripples out gladly' ('Hän heläyttää iloisesti', HS 12.5.2002).

One main result of the study was the diversity of the representations of female scientists, as compared to the US studies. The largest group of the interviews was classified as 'ordinary researchers in their work', not as exceptions. However, the femininity of female scientists was stressed both explicitly and implicitly by various linguistic means. Stressing femininity is a double-faced issue: it includes both empowering and stereotyping aspects. Still we suggest that the diversity of the media images of female scientists provides important role models for young women, encouraging women to choose science as a profession.

Husu, L. & Tainio, L. 2007, 'Representations of women scientists in Finnish print media: Top Researchers, Multi-talents and Experts', in L. Mattfolk, S. Nordlund-Laurent & J.O. Östman, eds. *Language, Politeness, and Gender*, Nordica Helsingiensia, University of Helsinki, Helsinki.

Gender stereotypes are deep-rooted perceptions of male and female characteristics, but they are socially constructed and permeable to change over time. Research has focused on analysing the reproduction of gendered stereotypes, showing the persistence of subtle and cumulative mechanisms that operate in different domains of social life (family, school, peers and leisure activities). The meta-analysis of the literature shows that less attention has been paid to patterns of change and the unintended effect of some research and policy approaches which, while explicitly attempting to challenge stereotyping, in fact reinforce it instead.

Changing stereotypes

Research on the historical change of stereotypes focuses on non-traditional gendered stereotyped choices. While fields such as engineering and ICT remain male dominated, women's representation in many areas previously dominated by men, such as medicine or biology, has increased in recent decades. This shows how gender differences in career interests are not fixed but subject to the influence of social forces (Xie, 2006), although the factors that account for this change remain largely under-researched. The literature nevertheless shows the fragility of what sometimes lies behind stereotypes. In

Portugal, for example, where currently almost half of the doctors are women, dentistry is a male-dominated field whilst clinical haematology is female-dominated. As Bettio and Verashchagina (2009) ask: is this evidence that dentistry requires less care and involves less emotional work?

The literature also acknowledges that the process of change is slow and needs to be continuously reinforced. Mechanisms such as the 'stereotype threat', which refers to the experience of being in a situation where one faces judgment based on societal stereotypes about one's group (Spencer et al., 1999), have been identified as a barrier that limits women's performance and expectations in science-related fields (Schmader, 2002). Most importantly, research shows that while gender stereotypes may change, gender stereotyping persists. The example of medicine illustrates that gender stereotypes within professions are related to the gender composition and the

status of men and women in terms of power relations, hierarchy and authority (Ortiz-Gómez et al., 2004). Throughout history, different health professions have built masculine or feminine professional identities. The achievement of this identity is based on the selection of the members of the professional group on the basis of their gender as well as on the incorporation of gendered values into healthcare. There has been an active and historically changing process by which values and behaviours (masculine and feminine) transform the profession and the medical specialities (e.g. the diagnosis and empathic treatment area, introduced in the 1920s, was defined as more 'feminine', intuitive and less scientific). The interest in the construction of gendered professional identities in health has led to studies investigating dominant female identities in certain specialities. Research has also focused on the processes by which male identities are shaped in medicine, dentistry and surgery, while historically functioning as

Box 14. Academic excellence: a family affair?

This book tries to unveil the secret formula that produces the most emblematic representatives of French academic excellence: the science students at the elite higher education school École Normale Supérieure of rue d'Ulm. This article does not aspire to explain the extreme singularity of these paths, let alone to produce a single formula for success, but to analyse the stories of these students and their parents in terms of different kinds of family inheritance, different intensity and ways of working in order to understand what it takes to produce a male 'normalien' or a female 'normalienne'. At this level, excellence is definitely a family affair. Like the graduates from the other elite schools (Grandes Écoles), science students attending the École Normale are heirs. More specifically, however, who are the heiresses? Since the fusion of the sections, Sèvres (for girls) and Ulm (for boys), girls have become a rare species in mathematics and physics. Did the ones who resisted eviction have extraordinary academic and social assets? In spite of conducting a meticulous research study, the authors, as Christian Baudelot states in his preface 'came back empty-handed from searching for the one tiny element that makes all the difference'. Girls and boys are in fact astonishingly similar except in one crucial aspect: it was found that whatever the social background they came from, the girls enjoyed an education that disregarded gender stereotypes.

Ferrand, M., Imbert, F. & Marry, C. 1999, *L'excellence scolaire: une affaire de famille: Le cas des normaliennes et normaliens scientifiques*, L' Harmattan, Paris.

a way of increasing the prestige of the activity (Ortiz-Gómez & Bernuzzi, 2007).

In the historical construction of stereotypes, especially telling are examples of the explicit and intentional construction of stereotypes such as that of 'Rosie the Riveter' analysed by Honey (1984). In order to deal with the shortage of men in factories during the Second World War, the media first created the female 'riveter' –a woman also able to do men's work– and then demolished it once the war was over. As Bettio and Verashchagina (2009, p. 40) contend, this example illustrates that 'history is needed to explain how a particular occupation has come to be associated with one or other sex. In other words, explanations based on stereotypes are either very general or they are detailed but *ex post*. At practical policy level, however, the message from the literature on stereotypes is clear: implementing processes that use education or the media to remove the association between given occupations and womanhood can go a long way towards de-segregation. Akerlof and Kranton [2000], for example, credit the American feminist movement with having weakened this association in the 1970s, when indices of segregation recorded their first major decrease since early industrialisation'.

Reinforcing stereotypes

Research and policy making meant to challenge traditional stereotypes may have the unintended consequence of reinforcing them, when they either explicitly or implicitly resort to a type of social and educative 'essentialism'. This essentialism uses policy making to break down learning styles, skills, interests or motivations, some of which are associated with boys and others with girls. The main bulk of research from this approach comes from the analysis of the school's role in the educational choices of girls and boys. It is argued, for example, that the approaches

that propose catering for more 'feminine' learning styles explicitly or implicitly resort to dichotomous stereotyping according to which girls are better at social relationships than boys, but have more difficulties in dealing with abstract knowledge (Mendick, 2005). In this way, these approaches contribute to reinforcing gender stereotyping among adolescents, teaching staff and families.

One strand of the literature seeks to go beyond this essentialist utilisation of gender and develop an alternative approach to the underrepresentation of women in scientific-technical studies, with a focus on the 'hidden curriculum' in primary and secondary education (Norton, 2004). Research shows first the need to understand gender as an analytical concept which is not linked to a series of fixed characteristics attributed to girls due to the mere fact of being women or boys simply for being men. On the contrary, gender should be understood as a negotiation process that emerges in specific situations and in different ways depending on the setting (in the family, the workplace, in school...). In this way, gender is understood in terms of relationships and interactions and not of individual features (Boaler, 2002). Secondly, research suggests the need to connect the gender perspective in the study of knowledge transmission methods to power relationships and to different forms of inequality. This means that girls and boys should not be understood as two homogeneous groups. Gender should not be dissociated from other types of inequality, such as class and ethnicity. According to this type of approach, the objective of analysing the methods by which learning contents and contexts are transmitted is not to 'feminise' pedagogies and knowledge transmission styles, but rather to introduce pedagogies and learning environments that are more inclusive, capable of overcoming power relationships and social inequalities in the classroom (Norton, 2004; Paechter, 2003).

The risk of reinforcing gender stereotypes is also implicit in some research and policy approaches that intend to support women's career advancement in science. Research suggests that one important differential factor between men and women in science concerns the self-conception of one's own ability. Women's more defensive self-presentation, their more modest dealings with competitive situations and their underestimation of their own capabilities are well established facts in the socio-psychological research literature (Abele, 2002; Eccles, 1987). However, a large strand of research takes on an essentialist approach and fails to acknowledge the extent to which these differences are the result of the internalisation of social pressures and unequal power relations in science and society at large.

Policy measures built on this essentialist approach may be counterproductive. As stated by Corneliussen (2009) in the case of Norway, one of the important findings from the evaluation of equality measures is that they are not value-neutral; strategies to include or retain women also contribute to constructing particular perceptions of gender. Despite being well-meaning, gender equality policies are often built on dualistic and rather stereotypical notions of gender, poorly equipped for making long lasting changes.

Boys' atypical choices

Research focuses on girls' choices and interests, but horizontal segregation in education is

Box 15. Just how male are male nurses...?

The aim of this study was to elucidate, quantitatively, the gender role perceptions of male nurses in Ireland. Caring, women and the female gender role are all historically and fiercely synonymous. However, not all carers are women. For instance, male nurses also assume caring roles. What we do not know is how these men actually relate to their own gender role. Is it possible that because of their immersion in a stereotypically caring career they actually occupy the female gender role? A quantitative non-experimental descriptive design was adopted. Short-form Bem sex role inventory was mailed to a random sample of 250 male registered general nurses in Ireland to ascertain whether they perceived themselves to occupy the male or female gender role. One hundred and four men completed the inventory. Overall, the sample identified with more female than male gender norms. Specifically, 78 respondents identified themselves as adhering to more female gender role norms than male gender role norms, whereas 21 respondents identified more strongly with male gender role norms. Five respondents identified equally with both gender roles. This study quantitatively elucidates the gender perceptions of male nurses in Ireland for the first time. Adherence to the female gender role may be an important prerequisite to caring. If this is true, then this study supports the notion that many male nurses occupy this gender role. However, adoption of facets of the female gender role may not be unique to male nurses. Many men may occupy this role and perhaps resultantly be attracted to or well-suited to caring careers. Attracting such men may help in solving the recruitment and retention issues that surround caring careers. Furthermore, the attraction of more men to caring careers may subside the stigma for the minority of men already in such careers.

Loughrey, M. 2007, 'Just how male are male nurses..?', *Journal of Clinical Nursing*, vol. 17, no. 10, pp. 1327-1334.

also due to boys' choices. Research on this issue is scarce, but nevertheless points to greater social pressures on boys to maintain traditional gender-role stereotyped behaviour and choices (Massad, 1981). Some studies suggest that girls are not only interested in a significantly greater number of careers, but also show greater gender-role flexibility in their career aspirations. Other researchers report that, mainly as a result of the persistent devaluation of activities performed mostly by women, women have more incentives to enter male jobs, while men have little incentive to embark on traditionally female-dominated studies and professions. Clearly, the increased similarity in the career aspirations of gifted boys and girls is attributable to girls becoming more interested in male-dominated occupations, rather than vice versa (Leung et al., 1994).

However, little is known about the factors that might influence men to enter gender-atypical fields of study (such as nursing, librarianship, elementary school teaching and social work) (Chusmir, 1990; Hayes, 1989; Jome & Tokar, 1998; Lease, 2003; Lemkau, 1984). Whereas women who choose to enter male-dominated occupations are generally viewed as making a positive career move (Hayes, 1986), the same perception does not hold true for men who enter female-dominated occupations: they may, for example, face lower status and financial rewards, and even find their abilities, masculinity or sexual orientation questioned (Chusmir, 1990; Hayes, 1986 and 1989). Indeed, some research suggests that there is a stigma associated to men in these professions, not considered 'real' jobs for men (Williams, 1992).

2.2 The 'rush hour' in academia

Gender differences in career trajectories are closely linked to gender differences in the timing of events, the prioritising of roles and social relations across life courses. A significant

amount of the literature points out that the scientific career takes the traditional life course of men as the norm; this entails difficulties for combining professional and personal lives for scientists of both sexes, but in the context of the gender division of labour this conflict disproportionately affects women. Particularly, the greatest pressures for achievement and embarking on a scientific career coincide with women's childbearing years and the social expectations about the right moment to have a family, in a context in which women continue to bear the primary responsibility for caregiving and housework. Therefore, research has paid particular attention to this moment, which has been called by some authors the 'rush hour', understood as the life stage in which women's family and academic requirements most often collide and decisions related to having children and developing their academic career must be taken (ESF, 2009). In this chapter we review this strand of the literature, on the basis of the report on science as a labour activity by Caprile and Vallès (2010).

It is already well acknowledged that the sciences have developed historically in the absence of women while taking men as the norm. The recent US report *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering* (NAS, 2007) provides a critical insight into the underlying assumptions of the ideal academic career from a gender perspective.³ The model of the 'ideal scientist' that prevails in academia is based on the expectation that the scientist will have an unlimited commitment to science throughout the entire working life. In this way, the traditional scientific career presumes the model of an out-of-date male life course. Attention to other serious obligations, such

³ The report was issued by the Committee on Maximizing the Potential of Women in Academic Science and Engineering, National Academy of Sciences, National Academy of Engineering and Institute of Medicine. Although it refers to the situation in the US, the trends depicted may be applied to academia in general.

as the family, is taken to imply a lack of dedication to one's career. Historically, this career model has depended on a scientist having a wife to take care of all other aspects of life, including the household, family, and community. The model still applies to some men but is increasingly unsuitable for both men and women who need or want to participate in other activities. This assumption is valid in all European countries, in spite of cross-national variations in scientific systems. Being a good scientist means total dedication to work and the relegation of one's private life. Long work days are accepted as the norm and, therefore, as a norm that must be complied with (Currie et al., 2000). The same holds true for complete availability: issues such as a 'long hours culture' entailing presenteeism and unsocial work schedules, the 24/7 professional who is constantly 'on call' or geographically mobile (in search of career advancement, or operating internationally) are phenomena which have been observed in academic institutions (Ackers & Gill, 2005; Griffiths et al., 2007; Halvorsen, 2002; Ward, 2000). The commitment to science also means availability to meet informal demands for relationships, networking and engagement in the scientific community.

A second feature of the normative scientific career is its rigidity. The scientific career is conceived as a rigid sequence of educational and occupational stages that are expected to be achieved at a certain age. Deviations or delays are taken to indicate a lack of commitment to the scientific career and are thus penalised (NAS, 2007). The sequence of stages varies across the European countries, but rigidity is always the norm. The rules for access to grants, fellowships and tenured positions are usually defined in terms of age or time elapsed since the achievement of academic degrees or the recruitment to academic positions. These rules may be strict and legally binding or simply apply as institutional expectations, but they penalise

those who take longer to reach the threshold. Emphasis on steady and continuous research activity is one of the key elements taken into account for recruitment and promotion procedures: the timing of women's life course events, which is often influenced by biological constraints and social expectations concerning maternity, is a deviation which, at best, is taken into account but never seen as the norm (Thorvaldsdóttir, 2002 and 2004). However, there are substantial differences in the age at which a scientific career is expected to 'take off', and these differences may have important consequences in terms of gender equality. The same holds true for other age or time bars, which may be more disadvantageous for women in some countries than in others (Osborn et al., 2000).

Caregiving symbolically conflicts with the ideal of unlimited dedication to science. Beyond actual time and mobility constraints, difficulties in combining professional and family roles may also be the result of prejudices. In academia, caregiving is often seen as competing for the time and attention needed to succeed in highly competitive fields and, therefore, as indicating a lack of commitment to the scientific career. Prejudices against caregiving may exist and disadvantage women, even when caregiving does not imply less effort in the scientific career (NAS, 2007). In the English language literature, the 'maternal wall' concept refers to the complex of constraints and biases that women encounter when attempting to pursue scientific or engineering careers while also assuming major childcare responsibilities. Maternal-wall bias in academia is typically triggered when a woman becomes pregnant or requests maternity leave. At each point, maternity may entail negative competence assumptions and a distinctive maternal-wall catch-22 (Williams, 2004). Research has shown that the maternal wall, or family responsibilities discrimination, penalises mothers, women in general as potential mothers and fathers who seek an active role in family care.

Box 16. A male career model

An article in Portuguese answering the question: what are the factors responsible for inequalities between men and women in science and the academic career is *O género na ciência – o caso particular da Universidade do Minho* (Gaio dos Santos, 2002). With the aim of ascertaining what discriminatory factors were present in the Portuguese academic context, thirty two interviews were given to teachers of Minho University. Data obtained through the interviews show that women in this sample, experience the work-family conflict more acutely, because they must divide their time in a great diversity of contexts, while they are required to comply with a model of a male career which assumes absolute dedication to a career that is supposed to be uninterrupted. At the same time, the teaching overload and the absence of team work are pointed out by the individuals interviewed as some of the inhibiting factors of their scientific productivity; these factors seem to particularly affect women. Besides, 'subtle' messages transmitted by academy that the maternity option is incompatible with the development of a successful academic career, together with the absence of a real policy of family support continue to penalise women much more than men.

Gaio dos Santos, G. 2002, *O género na ciência – o caso particular da Universidade do Minho*, APS, CDROM.

These institutional constraints have a different impact on women's careers at different stages of the life course: they appear to be particularly acute in the early years of the scientific career, between the first university degree and first tenured position, which are the years in which parenthood and professional dedication conflict most. In the following sections we review the literature that explores two basic research questions: Do women have to make different choices from men concerning their personal and professional life courses? What is the relationship between 'demographic' variables and career outcomes?

2.2.1 *Personal and professional choices*

For both men and women, career paths in science are not linear or continuous but rather turbulent, with some stages and points which are particularly critical for the continuance of their scientific career. Of particular importance are the three critical transition points (®) that

mark the subsequent steps of standard career advancement:

PhD → Post-doc → Independent Researcher → Professor

Research shows that in each of these transition points, more women than men give up, are expelled or are not promoted (NSF, 1994; NAS, 2007; ESF, 2009). Differences are already acute in the early stages of the academic career, a long period of career formation with intense productivity and mobility demands. It encompasses the process of obtaining a PhD, carrying out fellowships abroad, being recruited as a post-doc in a scientific institution and competing for a tenure-track position. Access to an independent research position (i.e tenure-track or tenured) is indeed one of the major critical points (Blickenstaff, 2005; ESF, 2009; Martínez et al., 2007). The timing of this period varies considerably across European countries and scientific fields, but 25-35 years, sometimes even 40, might be taken as the common rule. It is a deeply-rooted assumption

that future career progression relies very much on performance in this period, a fact that disadvantages women: in addition to biological childbearing, most women continue to bear the primary responsibility for caregiving and household responsibilities.

Combining the pressures of the tenure time-line with the formation of a family and bringing up children appears to be especially difficult and requires women developing sophisticated coping strategies to manage all of their demands successfully. Research shows that many women face this time as a 'choose-or-lose' dilemma of either having a family and children or striving to achieve a top position in science. The paradox is that this dilemma, spurious as it may be, has extremely serious consequences: whilst there is no conclusive research about the impact of maintaining the 'dual role' on women's dedication to science and scientific production, it has nevertheless been confirmed that there is a link between the research profession and family choices –female scientists are more often unmarried and childless than their male colleagues and than women in general (Palomba & Mennitti, 2001).

A large number of publications deal with women's reconciliation of motherhood and a science career in the context of the gender division of labour. Many of these studies are interested in women's preferences and choices, but nevertheless fail to analyse the systems and structures which act to constrain them. This has also been the prevailing view in academic institutions. As Connolly and Fuchs (2009, p. 59) contend, 'how scientists manage to reconcile domestic and family (and other) responsibilities has long been considered a purely private matter by academic employers. Women's attrition from science was explained by 'choice' or 'deficit'. Academic and scientific organisations were either unaware or blind regarding their own

contribution to gender inequality'. However, not only do other studies show that this dilemma is gendered, but also that it is exacerbated by institutional constraints and implicit academic norms, values and expectations that take the traditional male life-course as the norm. Several studies, therefore, adopt an organisational approach to analyse the 'myth' and the reality of total availability in the scientific lifestyle from a gender perspective (e.g. Beaufaj's & Kraiss, 2005; Buchmayr & Neissl, 2006; Hasse & Trentemøller, 2008; Krimmer & Zimmer, 2003).

In this section we revise the literature that addresses the family-or-science dilemma, dealing with both women and institutional constraints. Four themes emerge from the literature review: first, the evidence of the dilemma as such, through the analysis of gender differences in the scientist's perceptions and family status; second, the variety of institutional constraints and academic cultures across national contexts and scientific fields, which give rise to a more or less acute dilemma for male and female scientists; third, the relevance of family-career tensions among the reasons behind leaving academia or pursuing a non-conventional path and finally, the variety of family arrangements among scientists and its impact on their professional and personal lives.

Family-or-science dilemma

Research provides clear empirical evidence of the extent to which the role conflict influences women's life course compared to men's. The wish to enjoy a family life in the framework of the prevailing gender unequal relations compels some women not to engage in research, to withdraw from science or to stop their progress, whereas other women make the choice to postpone motherhood to a later age or not to have children. A large number of studies, mainly at

the national level and dealing with a specific scientific field, show that: 1) A significant proportion of women withdraw from or stop their progress in the scientific career when they decide to form a family and have children (e.g. Athanasiadou, 2002; Glover, 2001; Ledin et al., 2007; Tupa & Šaldová, 2004; Xie & Schauman, 2003); 2) Women scientists have comparatively fewer children compared to their male colleagues and women in general. While male scientists have children at the same rate as the rest of the population, the fertility rate of women scientists is substantially lower (Blackwell & Glover, 2008, Buddeberg-Fischer et al., 2003; Carabelli et al., 1999; García de Cortázar et al., 2006; Glover, 2001; HCST, 1995 and 1998; Palomba & Menniti, 2001).

There is no systematic evidence of change over time, but as in other professional fields, it is clear that the intensity of the conflict is diminishing in a process parallel to the increasing presence of women in science. Recent research states that women's professional and family trajectories are more closely aligned than ever to that of men (Alaluf et al., 2003b; Lind, 2006). For example, Durán (1972) highlights that in 1967 in Spain there were only 9 female full professors, all of whom were single and without children. Nowadays 1,400 women, most of whom have children, are full professors: at the CSIC, the largest public research institute in Spain, only 1 in 5 female full professors does not have children, although this rate is still significantly higher than that of their male colleagues (7.5%)

Box 17. To become a mother is risky for career advancement

This is a book about women who have completed their doctoral dissertations at the University of Jyväskylä, Finland. It deals with what doctoral studies and examinations mean today for the women who have obtained their doctorates. The number of women holding doctorates is increasing steadily, and in Finland today this group constitutes almost half of such degree holders. But despite their growing proportion, there are still many hindrances to their academic and professional careers. In addition, they face the challenges of their everyday life as women. Universities are currently undergoing considerable changes and the status of the doctoral examination is declining. The doctoral examination is one of the quantified and central results of Finnish universities and part of a control mechanism. The empirical section of this book is based on a survey of 352 women doctorate holders and a university student register. The subjects dealt with in the questionnaires included working on the dissertation, feelings about this, career, work, family, support and discrimination, work life satisfaction, working time and others. The results show that the university is still male dominated, although it is easier today for women to obtain their doctorates. Working in the university requires a competitive attitude, flexible working arrangements, a setting aside of one's private life and total dedication to work. Combining work and family life is difficult. Becoming a mother under such circumstances can jeopardise a woman's career prospects. Indefinite work contracts are available for only a few doctorate holders. However, women satisfied with their careers were also found among those surveyed.

Julkunen, R. 2004, *Hullua rakkautta ja sopimustohtoreita*, SoPhi 96, Jyväskylän yliopisto, Jyväskylä.

(García de Cortázar et al., 2006). Other studies analyse the sociodemographic trends of scientists across time, reaching a similar conclusion. Gjerberg and Hofoss (1995) showed that in Norway a larger percentage of female than male physicians live alone, although the percentage of single people was larger among older than among younger female physicians, a fact that suggests that the need to choose between career and family is not as strong as it used to be.

Several studies refer to a deep generational change as regards career and family balance (see Etzkowitz et al., 2000 in the US and European comparative studies such as Caprile et al., 2008b and Hasse & Trentemøller, 2008, among others). Whilst older generations of women scientists adopted highly competitive strategies in line with the masculine ethos of scientific work, many young women and some young men nowadays appear to have a more balanced life and do not accept the fact that they have 'to pursue research as the main aim of life' (Ajello et al., 2008). A considerable proportion of young academics of both sexes find the relationship between home and work in science unsatisfactory and unhealthy (Sturges & Guest, 2006). Hasse and Trentemøller (2008) contend that family issues have entered science for both male and female scientists: the system defines the good scientist as a male who practises a clear distinction between work and family life – and has complete dedication to work. This sets up a boundary between males and females in general, but also between the males who fit this stereotype and the new masculinities which have different values. Some young male scientists are also interested in being able to be with their children and give high priority to family life.

In general, research shows that these wishes collide with increasing competitive pressures in science and are not welcome in most academic institutions; this leads young scientists, and particularly women, to feel

they have to make an 'either-or' decision between career and family (see e.g. Fuchs et al., 2001; Lind, 2008; Metz-Göckel et al., 2009). A comparative analysis between the US and Israel concludes that women in both countries face a practical dilemma in combining a career with a family as well as a femininity dilemma related to their identity as women (Etzion & Bailyn, 2006). The comparative study of Caprile et al. (2008b) stresses that many young female scientists claim that they are not prepared to give up their personal life as some of the senior women scientists had and view their professional future with frustration because they realise that balancing their personal and professional lives in the long term is not an established practice and does not lead to a successful scientific career. In a similar vein, Lützen and Larsen (2005) analyse the perceptions of PhD students in Denmark, showing that women are more sceptical of the academic environment and they do not want to sacrifice their family for the benefit of their career. The common perception is that only the most dedicated women make it to the top positions, but that they make great sacrifices along the way – so much so that they are not good role models for other women. Julkunen (2004) showed that young women regard the Finnish university as an extremely competitive environment that makes motherhood risky for career advancement. Beaufaj's and Kraus (2005) suggest that academic culture in Germany has a strong bias against motherhood. The ideal of total availability, so deeply entrenched in the scientific lifestyle, penalises women, regardless of their family status. Perhaps not so paradoxically, the authors consider that this is more detrimental to potential mothers than to those who are already mothers. Women with children may demonstrate through their scientific work that they are as competent as their male colleagues. However, many young women end up believing that science is incompatible with family life and they feel that they have to leave academia if

they wish to have a family. Drews and La Serra (1994) showed indeed that parenthood has for a long while been a 'hot issue' in German universities. They surveyed male and female students, junior researchers in temporary positions as well as parents of small children and found overwhelming agreement: the university must become aware of the 'child care question'.

There is also evidence of a clear shift in Eastern countries in the framework of the sociopolitical changes that have taken place following the socialist period: research highlights a pervasive change in the vital strategies of young women scientists, who tend to give higher priority to their professional career over the traditional gender roles of spouses and mothers, delaying the age at which they marry and have their first child (Blagojevic et al., 2003; Mařicová, 2004; Tornyi, 2007). Along the same lines, Balahur (2008) showed that in Romania the difficulties perceived in reconciling a career and bringing up children are important de-motivators that drive women away from a career in science and technology. Overall, it is stressed that men and women do not face the same dilemma between their professional and personal choices in the early years of the scientific career. In contrast to the metaphor of the pipeline, Šaldová (2007) uses the metaphor of science as a labyrinth, in which it is easy for young scientists to get lost, especially women aiming to combine the building of a scientific career with the formation of a family and having children.

It is commonplace to stress how early on in their careers women anticipate the role conflict. However, other studies draw a more complex picture and show that career-family tensions cannot be overstated. Longitudinal research on doctors in Norway (Gjerberg, 2002) contradicts the idea that the low proportion of women in male-dominated areas of medicine like surgery is only due to this kind

of constraints. Women were found as likely as men to start their career in these fields: the main problem was their not completing specialist training. The study shows that the reasons for this are complex. Heavy workloads with duties and nights on call make it difficult for women to combine childcare and work and make them change to other specialities. Also, female specialists in surgery and internal medicine tend to postpone having their first child compared to women in other medical specialities. However, the fact that many women change from surgery to gynaecology and obstetrics, a speciality with similar workloads and unsocial schedules, shows that structural barriers in combining childcare and a hospital career do not fully explain the flux of women.

Institutional constraints and departmental cultures

The lack of widespread socio-structural mechanisms to provide better management of the compatibility of family roles with academic careers is an important obstacle to women's advancement in science (e.g. Acar, 1994; Forster, 2001; Kramer, 2000; Lind, 2008; Ulmi & Maurer, 2005). It is a general trend, although the literature highlights that the role conflict may be more or less pronounced depending on institutional constraints and academic cultures, which show a great variety across national contexts and scientific fields. Indeed, the scientists' family status presents striking cross-national differences, as Le Feuvre (2009) points out. In Germany, the typical male professor is a family man with two or more children, whilst half of the female professors do not have children (Zimmer et al., 2007). In contrast, the percentage of professors in France who do not have children is similar for both sexes (about 13%) and men are somewhat less likely than women to have had two or more children (64% of male professors, 69% of women professors).

These differences suggest that the structural conditions of the academic career track, which vary greatly across Europe, have a considerable impact. Countries such as France, which offers stable employment relatively early on in careers, are more favourable to female scientists than systems such as the German one, in which a succession of temporary jobs is particularly difficult for women to negotiate at a time when family responsibilities make them less mobile (Beaufaÿs & Kraus 2005; Cheveigné, 2009). Majcher (2007) points out that academics face more acute career and family tensions in Germany than in Poland. Her study is based on two national surveys that investigated career development, recruitment procedures, professional performance and the work satisfaction of male and female professors in both countries. The comparison draws on the fact that there are certain similarities between the two university systems (the Humboldtian University once served as a blueprint for the Polish system) and both have undergone a process of intense growth in the last two decades, which produced a situation of increased job opportunities for male and female scientists alike. Besides these similarities, however, the study stresses the striking differences related to the status of women in society and to academic recruitment procedures. First and foremost, the obstacles to attaining a secure and life-long academic position in Germany are considerable. Although women in academia face significant problems in both countries, a university career seems to be less risky and more woman-friendly in Poland than in Germany even though German society seems more aware of feminism and gender politics.

Beyond structural conditions, the literature also stresses the importance of academic and departmental cultures. Hasse coordinated a comparative study (Denmark, Estonia, Finland, Italy and Poland) on gender and academic workplaces in the field of physics (Hasse, 2008; Hasse & Trentemøller, 2008). Among all the

countries involved in the study, Denmark stands out as the country with the lowest presence of women at all academic levels. The study argues that this is at least partially related to the specific trends of academic culture in Denmark, which is highly individualistic and competitive in the initial stages of the academic career, making it extremely difficult to reconcile family and career demands. However, even in this context the study found a certain variation across departments, particularly relevant from the perspective of family and career tensions: 'In the physicists' 'folk-narrative' it is explained that women have problems because of children. This is not confirmed by this study, though. Instead we find that the context defines children as the problem. What is particularly interesting is that we find 'pockets' in physics where the physicists seem able to reconcile work and family life, avoid sexual harassment and in many ways seem to reconcile also the object of the activity with the community, the rules (implicit and explicit) and the division of labour without too much hidden competition. In the best practice examples we do not only see that the physicists can retain their love for physics, they also refer to a larger degree to the usefulness of their work, a strong feeling of group solidarity and being able to combine work and family life. Naturally the best practice groups are not all idyll because some people might not fit in within the boundaries of the group –and in this case they leave. But when we compare the 'complaining' quotes with our best practice examples we find another mind-set where both men and women feel comfortable –and in these groups we do not hear explicit examples of harassment in general, sexual harassment, nepotism or lack of understanding for family life responsibilities. The particular problem of an unsatisfactory social environment seems, in our analysis, to have been more or less solved in the pockets of best practice groups. Though many problems remain for male as well as female physicists (such as the short

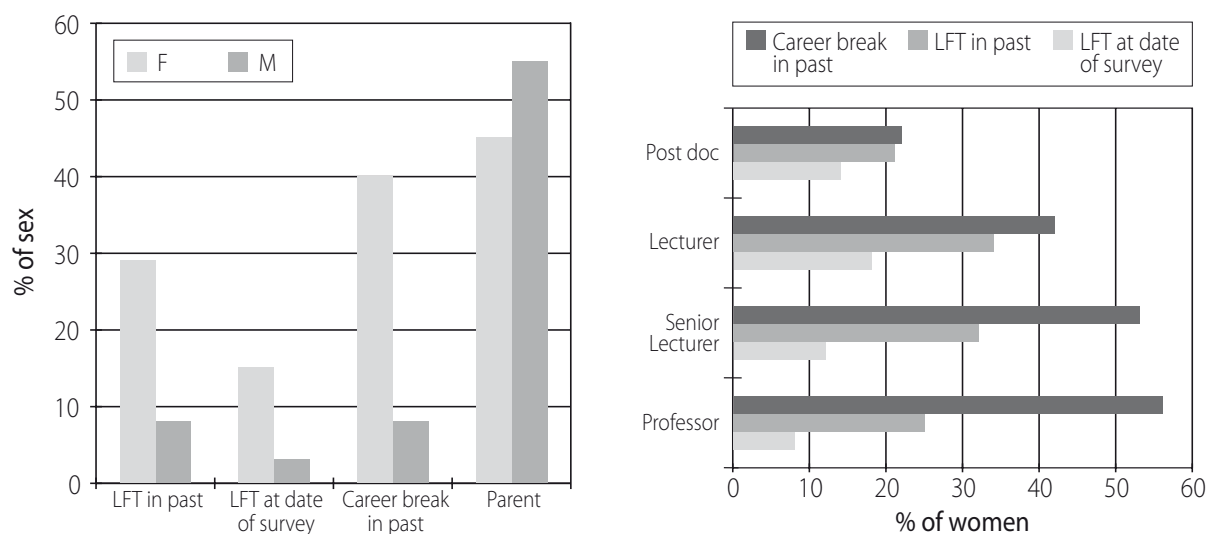
term contracts), these best practice examples show clearly that it is the workplace context for doing physics research which creates leavers, especially female leavers, rather than children as such, demands for travels abroad, and work hours' (Hasse et al., 2008, p. 123).

Career 'deviations' and leavers

In general, studies concentrate on scientists that pursue the most standard path and little is known about the numbers, paths and perceptions of scientists who leave the academic pipeline or fail to adjust to the rigidity of the academic 'tempo' (e.g. career breaks, part-time work during specific periods, re-entries to the career track at a late age, etc). The data is only fragmentary, but it shows that more women than men leave academia, whilst career breaks/part-time work due to family requirements are basically a women's issue. Although it is a commonly held belief that family-related issues account for the lion's share of career 'deviations' and leavers, a closer look at research in the field reveals a more complex picture (Mavriplis et al., 2010).

The data from the Athena Survey can serve as an example of the extent of gender differences in career breaks and part time work (Athena Forum, 2007; see figure 12 below). The survey provides comprehensive statistics about gender and working conditions in UK universities (not including the social sciences). In 2006 the survey covered more than 70 universities and about 3,400 respondents of both sexes. It shows that the percentage of men who have taken a career break is almost negligible as compared to 40% of female respondents, even if more women than men do not have children. The same holds for working 'less than full-time': almost 30% of faculty women had been in this situation in the past (less than 10% of men) and 15% when the survey was carried out (4% of men). The highest percentage of women working less than full time was at the lecturer level (18%). The survey further shows that a high percentage of women professors and senior lecturers had been working less than full time or had taken a career break in the past, a fact that according to the Athena report (p. 17) 'suggests perhaps that the 'non-traditional career path' is not necessarily a barrier to a successful career'. Connolly and

Figure 12. Career breaks and working less than full time (LFT) in UK universities, 2006



Source: Athena Forum, 2007.

Fuchs (2009) carried out the same survey in a European university and found similar rates of career breaks among academic staff (39% women, 5% men). However, they highlight that taking a career break is more feasible or more acceptable once scientists have achieved a certain level of seniority and have survived the early selection barriers. Yet, 20% of the women who had taken a career break reported that it had harmed their career. They also show that women that have considered but not taken a career break (16%) offer explanations that underline the 'either-or' nature of the decision, its close link to becoming a mother, and the anticipation that the decision is potentially harmful to career advancement. Overall, they find general disbelief among both male and female faculty that taking a leave would not harm one's career. Considering that career breaks are taken predominantly by women and almost exclusively for maternity leave, they contend that policies to support the work-family balance are important but also have the potential to increase existing gender inequalities.

Blackwell and Glover (2008) carried out a longitudinal study to analyse the patterns of retention of highly qualified women scientists in science-related employment in England and Wales. They compared retention in employing women with health-related degrees with that of women with degrees in science, engineering and technology, showing that the latter group had markedly lower retention rates. Differences in retention rates were found to be consistent with differences in family status. Those who stayed on in science-based employment have children later than other types of graduates and their rates of non-motherhood were also higher. Four-fifths of women in health-related occupations were mothers, compared to only two-fifths in science, engineering and technology.

One of the few comprehensive studies about leavers is that of Preston (2004), who surveyed

about 1,700 scientists (not including social scientists) and engineers in the US. Her study confirms that women leave science careers in greater numbers than men: in particular, female scientists wishing to work at the university were found to leave employment altogether at a rate of 14% and exit to another occupation at a rate of 18%, whilst these percentages were 4% and 15% for men. It is obvious that withdrawal from the scientific career by a person who has finished their doctorate forms part of the possible risks that exist in an academic career and quite often it is a frustrating situation in which it is difficult to distinguish empirically the 'push' and 'pull' effect. However, the study provides evidence of both types of factors, as well as of certain gender differences in the reasons portrayed: men complain more about low salaries and the lack of promotion perspectives, while women refer to a more complex set of reasons, including difficulties in balancing work and family life and a women-unfriendly environment.

Hasse and Trentemøller (2008) confirm these results in their cross-national qualitative study of reasons for staying in/leaving academic physics. More women than men are leavers or intend to leave, but leavers of both sexes refer basically to the same set of factors. Some of these seem to push physicists out of academia, while other factors outside academia appear to pull the leavers out of the university as a workplace. The lack of positions, the short-term contracts and better possibilities of getting a permanent position outside academia are some of the most frequent reasons given for leaving. Though leaving university, which in most cases is equivalent to leaving research, can be a difficult decision, the prospect of more harmonious work and family life reconciliation pulls some of the leavers out of academia. Interestingly, they find that a better work-life balance is a consistent 'pull' reason not only for many women, but also

men who do not adhere to traditional masculinity. Maternity leave is in many cases seen as a specific women's 'push' factor, especially for those on temporary contracts because they may lose contacts in academia or not be able to keep up to date with recent findings and write articles. Finally, women also mention another set of reasons related to the sense of not 'fitting-in', isolation and a lack of support, etc.

There is also fragmentary research, mainly in the UK, on the phenomenon of career 'slow down'. Research in this field usually focuses only on women, which is certainly a drawback: as Palomba (2008, p. 53) states, 'men who do not climb the career ladder are never interpreted as having made 'a choice' with respect to other social dimensions in their lives'. Still, studies point to a mixture of women's choices and constraints. Forster (2001) analysed the conflict between the personal and professional life of academic women in the UK, finding that some of the women reported that they had opted to put their careers on hold because of domestic and family responsibilities and a few have resigned themselves to never achieving senior positions because of these commitments. Evans et al. (2007) or Glover (1999) suggest that some women make a deliberate decision to 'tread water', staying at a level which is below their proven or predicted potential in order to maintain a workable balance. In Eastern countries, several studies highlight that a lack of support, poor career prospects as well as family-related constraints often lead women to lower their professional ambitions and adapt themselves to the status quo rather than striving for higher positions in their careers (Kornhauser, 1997; Šaldová, 2007).

Godfroy-Genin (2009) shows how the phenomenon of 'working below potential' may be interpreted in different ways and highlights the need for further research. Building on the results of the *Prometea* study

of women in engineering research, she concludes: 'From our interviews on what 'career' means for researchers, it is clear that there are different ways to make a 'good' career. We could identify at least three different profiles with different personal agendas. The 'star researcher' is often the most common successful profile we think of: he or she has written lots of well-known publications, became director of an important research centre, a member of the academy of science, and has discovered something which brought him/her a famous prize or a rewarding patent. The challenge lies in discovering other profiles and not obliging all researchers to stick to this role model. The 'administrator' may be another figure: he/she is a successful administrator of research, managing a laboratory and finding funding and positions to develop further activity. A third profile also seems to be a very successful one among researchers, even if it is not usually considered as brilliant as the others: we could dub it the 'quiet researcher', somebody who is focused on research itself and intellectual interest but does not want to spend too much time in administrative or managing tasks and chooses to preserve a satisfying work-life balance even to the detriment of his/her career. This is the case of numerous associate professors we have met and who declared that they were not interested in becoming full professors and were pleased with their current position. This is what they stated in the course of interviews, though it may be a way to turn personal failures or lack of ambition into something more positive. We do not know to what extent interviews are sincere and unbiased. Facts and representations and social desirability are always interfering' (Godfroy-Genin, 2009, p. 94).

Family arrangements

Female academics living with their partner are significantly more likely than their male counterparts to be part of a dual career couple,

Box 18. Researchers between two passions: The example of biologists

The academic world does not escape the 'glass ceiling' or the 'leaden sky' that weighs upon women's careers: in all fields, their presence declines as one rises in the hierarchy of ranks and honours. On the basis of statistical data and interviews, this article offers possible explanations for these gendered inequalities in the academic world by exploring a corner of the leaden sky, the one that weighs upon female researchers in natural sciences in France. It focuses on the subjective dimension, i.e. on pleasure and suffering inherent to the profession of the researcher, as well as on the contradiction between the imperatives of an ideal researcher and that of a mother. Trying to provide sociological interpretations with respect to the 'glass ceiling', the authors deal with the theme of female productivity and of its potential limitations due to family obligations, then with the 'Matilda effect', that is to say the hidden mechanisms of male hegemony in academic organisations that keep women away from the better aspects of the career. The authors then focus on conditions of work, its location and intensity, in order to point out the situation of the women biologists, between two passions, the passion for their work and the one for their children, and the ways they articulate them.

Marry, C. & Jonas, I. 2005, 'Chercheuses entre deux passions: L'exemple des biologistes: Sciences, recherche et genre', *Travail, Genre et Sociétés*, vol. 14, pp. 69-88.

i.e. a couple in which both partners strive for career advancement. Yet, even in this situation women are usually found to be primarily responsible for domestic responsibilities (Sturges & Guest, 2006). In general, research indicates that this situation contrasts with the fact that many male scientists enjoy the support of a partner who is not working, working part time or has a less demanding job and who focuses mainly on the family and children. However, several studies provide a more nuanced and complex picture of dual career couples' family arrangements.

Marry (2001b) contends that homogamy is advantageous for women belonging to the professional elites. She carried out a study on male and female ex-students of the elite higher education school *École Polytechnique* to analyse family arrangements and career advancement and found that having a relationship with another ex-student was an advantage for women's careers. Although the

husbands' careers can be an obstacle for the wives, the study concludes that this process is less operative in the case of the elites. Gjerberg (2003) arrived at a similar conclusion analysing how doctors in Norway cope with their careers and families whilst Carabelli et al. (1999), having explored the situation of economists in Italy, found that women with children and not in an endogamous relationship were in the worst situation. Behnke and Meuser (2003, 2005) point out that in Germany dual couples are somehow 'lifestyle pioneers', who contribute to the modernisation and the de-traditionalisation of society, even if persistent gender differences are still present. Ajello et al. (2008) point out that in Italy physicists in endogamous relationships tend to share domestic responsibilities and to be more sympathetic to and tolerant with the 'busy' partner. According to Hasse et al. (2008), a tendency towards a more equal distribution of household tasks does seem to be present among young physicists compared to the

older physicists in Denmark. Godfroy-Genin (2009) points out that the 'top women' in engineering research often describe very supportive partners, alongside social networks, as the most important support in their career. It seems clear that dual career couples in science and new femininities and masculinities are in need of further research. In the field of dual career research and policy-making the US is clearly ahead (see Schiebinger et al., 2008).

A second issue that must be noted is that many more women than men, although satisfied with their careers, have to cope with a sense of frustration and uneasiness due to the difficult choices they have to make in their personal life course: on the one hand, they are reasonably happy about their careers; on the other, they experience with anguish or frustration the personal price they have paid or the limited amount of time they dedicate to their families and personal life. As Marry and Jonas (2005, pp. 85-86) state, 'nowadays there is in no country a direct causal link between women's success in science and children, but everywhere the work-life conflict is very strong in subjective terms. Without doubt, because women researchers share both the Weberian ethos of total devotion to science and the ideal of a mother completely devoted and available for her children'. As they note, the contradiction between these two imperatives is also dependent on material resources. Women engineers working in the private sector have more financial resources for developing coping strategies than women scientists in the public sector. This uneasiness is perhaps the most subtle issue, difficult to capture objectively, but it is, nonetheless, particularly important and emerges across numerous narratives and qualitative research findings (Athanasiadou, 2002; Etzion, 1988; Forster, 2001; Hablemitoğlu et al., 2004). Doyle and Hind (2002) confirm this finding, showing that academic women suffer higher levels of stress at work than men in similar positions. Research in the US points out that this

uneasiness is particularly acute at the mid-stage of the academic career (NAS, 2007).

2.2.2 Family status and career outcomes

One of the most common explanations for the differences between men and women's careers is the conflict between the professional and family role: the hypothesis is that marriage and especially motherhood have a negative effect on women's involvement in academic work and scientific productivity, in comparison with men, single women or women without children.

Xie and Shauman (2003) provide evidence that in the US, marriage and motherhood are related to lower career prospects in the case of women scientists. They found 'a clear and persistent pattern in which marriage and parenthood exacerbate gender differences, even after controlling for a variety of demographic and human capital explanatory factors. Gender differences among unmarried scientists are either small or nonexistent, but married women experience large disadvantages relative to men, especially if they have children. This interactive pattern results from two processes: the careers of men benefit from marriage and parenthood, while the careers of women are impeded by family responsibilities' (p. 152). In European countries, there is no possibility of carrying out similar comprehensive studies, as data concerning scientists' marital status and children is fragmentary. However, European research is far less conclusive on this point. For example, the longitudinal study of Abele et al. (2004) shows that motherhood may be a hindrance to an academic career in Germany, but women who do not have children do not reach the same level in their career as men. Overall, available empirical studies do not show any clear evidence that women without children have better career prospects than

their female colleagues, whilst it seems clear that successful men are supported by their family and the presence of children has little or nothing to do with their career opportunities (Palomba & Menitti, 2001).

In some European countries this fact has long been acknowledged –especially in Finland, where the National Committee appointed to monitor obstacles in female researchers' careers in the 1980s reached the conclusion that in a scientific career the greatest obstacle did not seem to be women's double burden, but rather their weaker and unequal position in the scientific community. On the basis of empirical studies, the Committee concluded that children and the family may slow down women's scientific careers, but they also seemed to have positive influences on both men's and women's scientific productivity (Husu, 2008). In spite of this, the prevailing view in academia is that women face more difficulties in reaching the highest scientific positions because they do not perform as well as their male colleagues due to having children and carrying out other domestic duties.

This section provides an overview of the empirical studies that address this question, focusing on those issues that have been more

extensively researched. The first of these refers to family-related mobility constraints, particularly acute in the early years of the scientific career. In the second, particular attention has been paid to age and time bars, which may have a disproportionate effect on women due to time spent on family-related activities. Finally, the literature has also explored the extent to which the levels of scientific performance of women with family commitments are similar to that of their colleagues, analysing trends as regards dedication, availability and scientific productivity.

Mobility

Beyond productivity pressures, the reconciliation of personal and professional lives is particularly difficult when young researchers need to move or relocate abroad. Geographic mobility is not the only career path to career advancement, but it is a common prerequisite for gaining access to tenured positions in some scientific fields, academic institutions or national contexts. Xie and Shauman (2003) show that in the US, women with young children are less geographically mobile than either women

Box 19. Managing relationships in peripatetic careers: Scientific mobility in the European Union

This paper seeks to add to our understanding of the concept of 'tied migration' through a grounded and essentially qualitative analysis of the experiences of highly skilled scientists moving within the European Union (EU). The propensity of the highly skilled to move and the consequences of this for individuals and their families vary significantly between different employment sectors. Progression in scientific careers demands a very high level of international mobility particularly in some national contexts. Whilst research suggests that young, single women are at least as mobile as their male counterparts, levels of mobility amongst women scientists decline at doctoral and post-doctoral levels. Locating the research findings within existing literature on 'tied movers', the paper considers the nature and impact of partnering on the career decision making of male and female scientists. It

concludes that the prevalence of dual science career couple situations (defined as situations in which both partners in a couple are employed in scientific research) reflects high levels of mobility and generates the kinds of tensions which result in the tendency of women to 'exit' from science careers and/or fail to progress. The findings reported upon in this paper confirm recent work on dual-career situations in noting the persistence of 'trailing' irrespective of the skill level of the female partner. It does, however, draw out some new issues. Firstly, the importance of considering the impact of mobility in the progression of trailing partners as opposed to simply engagement or salary. Secondly, in contradiction to recent work, the findings suggest that the impact of partnering (in comparison with parenting) has been underestimated when considering the mobility and career decision making of women in dual-career relationships. Although the paper is firmly based on the experiences of scientists, recent trends in European labour markets suggest that the pressure to attain international experience is beginning to shape career trajectories in many other employment sectors.

Ackers, L. 2004, 'Managing relationships in peripatetic careers: Scientific mobility in the European Union', *Women's Studies International Forum*, vol. 27, no. 3, pp. 189-201.

without children or men. In contrast, men scientists' propensity to migrate only becomes restricted when their children enter their teens. Restrictions to mobility due to bringing up children have therefore different timing for men and women. In the case of men, they coincide with the middle years of their career, a period of relative stability, whilst mobility constraints for women are especially acute during the early years, the time of career formation, when the lack of geographical mobility may be most detrimental to the scientists' future career.

Several studies in Europe confirm that women scientists have more mobility constraints than men, although parenthood is not the only issue considered. More young women than men tend to give up the possibility of mobility when they have children or when their partners will not move with them (e.g. Baptista, 2000; Cutileiro, 1987; Perista & Silva, 2004; Rodrigues, 2005). The inflection time in mobility comes at the PhD or post-doctoral stage. Young single women are at least as mobile as their male counterparts, but levels of mobility among women scientists decline at the doctoral and post-doctoral stages

(Ackers, 2004). Ackers also shows that women tend to be the trailing partner, regardless of their relative level of skills within the couple, suggesting that the impact of partnering (in comparison with parenting) has been underestimated when considering the mobility and career decision making of women in dual-career relationships.

Age and time bars

Recent research states that the age, duration and career planning of women is more aligned than ever to that of their male colleagues (Lind, 2006; NAS, 2007). However, women's childbearing years and the unequal distribution of domestic work are difficult to reconcile with what are considered 'ideal' rhythms of career, which usually imply promotion at a 'young' stage (Marry, 2005). As stressed by the ETAN report (Osborn et al., 2000), seemingly neutral age and time bars operate in this way as indirect forms of gender discrimination. Since age and time bars were first challenged in the 1980s in the UK, the general tendency has been to suppress or qualify them by introducing specific clauses

to take into account time spent on caring. In the late 1990s, following complaints of indirect discrimination, Dutch scientific institutions were pioneers in adopting the notion of 'academic age': men and women who can prove they had a time lapse in their career for reasons of care may be regarded as younger than the official age limits. Since then, some countries have offered researchers an extension of the academic age rules by taking into account childcare time when they apply for funding (e.g. Switzerland), or by abolishing the age limit altogether, and have offered appointments in combination with care responsibilities (e.g. the Netherlands) (ESF, 2009). During the second half of the first decade of the 2000s, the example was followed by some academic institutions in the Eastern countries, such as grant awarding bodies in Slovenia, Estonia, the Czech Republic (EC, 2009b) and, more recently, Hungary (Palasik, 2009). Recently, the Research Assessment Exercise in the UK also implemented the notion of 'academic age', rather than 'chronological age', for the assessment of the research output of academics (Bennett et al., 2010). However, these kinds of bars still exist in several countries, particularly for fellowships and examinations leading to permanent jobs. For example, the 8-year rule in Denmark states that scientists may only apply for an adjunct position within 8 years of graduation (Dons Jensen, 2009). Another example of rigidity is Austria: under the new University Act 2002, PhD and habilitation – that is, the prerequisites of an academic career – have to be met within 10 years of achieving the university degree (Leitner & Wroblewski, 2009).

Even when there are no bars strictly in force, the deeply-rooted assumption that future career progression relies on performance during the early years of the scientific career has a detrimental effect on women's careers: not being the 'right age' is penalised. Well-grounded evidence is provided by

Marry (2005), who analysed the patterns of promotion to grade A positions in the French CNRS. Her study stressed the attraction of 'meteor-like careers' for evaluators, although no age bar was officially in force. One of the evaluators is quoted as follows: 'In theory, age is not an argument, we try and concentrate on the scientific aspects of the work but, in practice, the profiles of young people who have rapidly published good quality articles are selected as future directors of large laboratories. It's true that when we run out of scientific arguments, we tend at the end, in this [disciplinary] section to be more impressed by people who have moved fast' (Marry, 2005; quoted in EC, 2008, p. 12). A similar conclusion is reached by Cheveigné in her analysis of the same institution: 'Age limits affect women more than they do men, whether official (such as the retirement age of 65 years, or the recently abolished rule for hiring a CR2 before age 32 years) or unofficial but imposed by the peer evaluation (such as the tacit limit beyond which it is 'too late' to be promoted to director of research, which varies with the discipline from about 45 to 55 years old)' (Cheveigné, 2009, p. 130). Finally, Delavault et al. (2000) also point out that age criteria may be tinged with subtle gender prejudices. In French universities, habilitation and promotion procedures to achieve a professorship are expected to be fulfilled between 25-40 years, with some variation according to discipline. However, this unofficial age criterion is not always applied in the same way to women as to men. It was found that evaluation panels raise the issue of maternity in the case of women 30-40 years old, whilst tending to consider 40-year-old women too old to be researchers, taking it for granted that the women have not been actively involved in research during recent years. On the other hand, 40-year-old male applicants appear to benefit from age, as if it were an indicator of accrued research experience.

Dedication and availability

In spite of the constraints that maternity may impose on women, there is no empirical evidence that women scientists with children working full-time spend fewer hours at work or work less intensively than their colleagues (Palomba & Menniti, 2001). Some studies suggest that men and women scientists with children, working full-time, spend the same number of hours in the work place, although women then dedicate more hours to childcare and household tasks than men (NAS, 2007). The overall picture is that university or public research institutes may offer, for scientists in intermediate positions, more opportunities for flexible working time and reconciliation than many other professional settings, although conditions for promotion tend to be more disadvantageous (Strehmel, 1997).

Such empirical studies suggest that the main difference between men and women does not lie in their dedication to scientific work, but rather on their availability. In other words, it is not about the number of hours dedicated to science, but about being able to attend meetings at unsocial hours, travelling abroad or engaging in networking activities outside of work. It appears that the 'ideal' of total availability for scientific work (outside of the workplace time and space) should be seen more as a symbolic input than as an actual requirement for scientific research. As Hasse et al. (2008, p. 122) state, 'we see that the need to spend time on non-workplace related activities also creates a boundary between those with less 'external time-demands' and those who are responsible for picking up children from day care, leaving work 'early', doing house chores, etc. These persons happen most often to be women, who are on the 'wrong' side of the borderline. Longer periods of time away from the workplace, e.g. maternity/paternity leaves, may analytically be seen in the same light. In this period of time

one cannot take part in networking (formally and informally), publishing articles and showing full devotion to the object of doing physics and this is problematic because all three aspects are part of the implicit and explicit competences that influence selection mechanisms'.

Indirect evidence of bias against caregiving is the disproportionate effect of working part-time on women's careers in some national contexts. Van der Burg et al. (1998) carried out a longitudinal study on academic staff members at Utrecht University and found that one of the main differences between men and women was that working part-time did not have any effect on the probability of men's promotion, although it did negatively affect women's. Whether total availability is a 'myth' or an actual requirement for scientific research, it seems clear that this work culture penalises women (Bailyn, 2003).

Scientific productivity

Academic performance is primarily measured by the number of papers, books and citations produced. In turn, these indicators are important criteria for recruitment, promotion and other forms of scientific recognition. Moreover, they are gaining weight as 'objective and neutral' indicators of performance within the current trend towards more transparent and accountable academic procedures that has been taking place in many European countries. It is therefore not surprising that a substantial amount of literature has been dedicated to the analysis of gender differences in scientific productivity.

Beginning in the 1970s and 1980s, several studies started to analyse scientific production by men and women, with contradictory results. Most of the evidence showed that, on average, women published less than men at a similar level (e.g., Cole, 1979; Cole & Zuckerman, 1984),

Box 20. Letter from a woman scientist

“The few women who stay in science and manage to combine family with work are often very productive. It is obvious that enormous selection has been exerted on the women who remain in science and you have to be highly motivated, highly committed and extremely well organised to survive. You also feel that you must be as productive as possible to convince colleagues that you should be taken seriously as mother and scientist. Looking at who stays in science is only part of the picture. If I look at my female contemporaries during my graduate and post-doctoral studies I am part of only ten per cent of those women who are still in basic science. Many of those have suffered poor career progression due to career breaks to have children. Many stopped when they had children and went into other careers when they went back to work, as they felt the break from research had been too long. In France my colleagues at the CNRS said they get about half the amount of their salary which they pay in childcare as a tax credit. This is in addition to a ‘child award’ of approximately £100 per month per child. How is France able to provide family friendly policies when the UK cannot?”

Letter from a woman scientist in her late 30s, working in an UK university with two small children and a partner also working as a research scientist.

Osborn, M., Rees, T., Bosch, M., Ebeling, H., Hermann, C., Hilden, J., McLaren, A., Palomba, R., Peltonen, L., Vela, C., Weis, D., Wold, A., Mason, J. & Wenneräs, C. 2000, *Science policies in the European Union: Promoting excellence through mainstreaming gender equality. A report from the ETAN Expert Working Group on Women and Science*, Office for Official Publications of the European Communities, Luxembourg, p. 69

although others such as Ferber and Loeb (1973) found that women were not less productive than men when other relevant factors were controlled and Reskin (1978) found that the discrepancy was smaller than usually supposed. In general, the prevailing view was that gender differences in scientific production had not been satisfactorily explained: their existence was said to be a puzzle (Cole & Zuckerman, 1984).

The studies that examine the relationship between marriage, children, and scientific productivity do not find that family factors have a negative effect on women’s scientific performance, particularly in terms of research productivity. Rather than hampering women’s scientific performance, marriage and children appear to be associated with equal or somewhat higher research productivity (Fox & Faver 1985; Kyvic, 1990; Luukkonen-Gronow & Stolte-

Heiskanen, 1983). Zuckerman and Cole (1987) examined the hypothesis that marriage and motherhood do not significantly affect women’s research productivity as against the widely held belief that marriage and motherhood are incompatible with a (successful) scientific career. They conclude that women publish less than men, but marriage and family obligations do not generally account for the gender difference. Married women with children were found to publish as much as their single female colleagues did. This was generally true for both eminent and rank-and-file women scientists. As Fox (2005) states, these counter-intuitive findings should be interpreted taking into account the over-selection of women scientists: they refer to the scientific productivity of women who have survived a rigorous selection process and manage to stay in science, while

family demands may take their toll along the way through graduate school and early career.

Recent US research sheds new light on this issue (Xie & Shauman, 2003). It shows that productivity is not an independent characteristic of individuals but rather a reflection of their position in the academic hierarchy and the access to resources that those positions make possible. When academic track, academic position, type of institution and available resources are held constant, men and women scientists are equally productive and family status (marriage, parenthood) has no impact on productivity. Some authors interpret these results in terms of Merton's concept of cumulative advantage (Merton, 1968; 1973): once a certain academic position has been achieved, its prestige leads to more invitations for research collaboration, to being quoted in colleagues' work and to receiving research funding, all crucial in getting published (Wennerås & Wold, 2000). As stated by Toren (1991, p. 654), 'if marriage and children have only a negligible influence on women's academic performance, then marriage and motherhood cannot be used to account for the persistent differential productivity rates of women and men, and its explanation will have to be sought in more complex social structures and processes [...]. To explain gender differences in academic careers and to gain better understanding of the incongruity between merit and rewards in academe in reference to women, we have to investigate complex mechanisms, such as discrimination, cumulative advantage and disadvantage, and changes in the opportunity structure through which these conditions are created and maintained'.

Gender differences in scientific productivity have thus been attributed to women's lower integration into the scientific community and low occupation of the highest academic

posts, such as influential posts in scientific associations or membership on editorial boards of journals (e.g. Bentley & Blackburn 1992; Luukkonen-Gronow & Stolte-Heiskanen 1983; Prpić 1992, 2002; Toren 1991, 2001). The study by Carabelli et al. (1999) investigated the career paths of Italian university professors based on longitudinal administrative records for the entire population of academic economists. It also made use of publication records drawn from bibliographical data banks and of a questionnaire administered to the female component in order to explore the importance of family conditions. Overall, the study suggests that supply-side explanations like motherhood or publications cannot fully account for gender differences in career outcomes. One of the main findings is that marital status or the size of the family (number of children) had no clear impact on publications or career progression. At the time of the study, in fact, more than one third of the female economists were single or did not have children; among women with children, moreover, the number of children increased both at the bottom and at the top of the publication records or the career ladder (Bettio, 1999). In general women were found to publish less, but, controlling for publication, the study found evidence of lower probabilities of climbing up the career ladder and concluded that one of the main factors involved was much weaker networking resources. The study conducted by Benigni et al. (1988) on researchers at the CNR, the largest public research institute in Italy, found evidence of exclusionary practices, as for the same productivity indexes women tend to receive less visibility, and consequently less power in guiding research.

Some studies have also found support for the negative effect of childcare on women's productivity when the children are small. Kyvik and Teigen (1996) found that women

Box 21. Only time and mobility constraints?

The University College Cork (UCC), in Ireland, commissioned a study to assess the participation of women in science, engineering and technology (SET). Although increasing, the presence of women was very low: In 2005, only 25% of the SET academic staff in UCC was female and the proportion of women in full professorships was only 11%. Several workshops were carried out targeting different groups of the female SET researchers in order to identify the main barriers to building a career. The conclusions for post-doc researchers were as follows: 'Concern was expressed about the lack of career path/structure or template for progression, and inconsistency in pay scales. As twelve monthly contracts were offered in most cases, there was no security of tenure or pension contributions, which resulted in a lack of stability. It was hoped that legislation on staff permanency might have an effect. It was considered that the university frequently loses the experience of post doctoral researchers (PDs). As it was necessary to 'get a foot in the door' in industry, there was a need to make the move early e.g. after a PhD. It was thought that experience gained in achieving a PhD was not accepted by industry. The lack of respect for PhDs should be countered and the university needs to educate recruiters regarding the valuable work of PDs. Family issues were considered to have more effect on women than men, and it was more difficult for women to combine their career and family. Anxiety was expressed about taking maternity leave as this might block career progression. Women with a family found it difficult to socialise after work and that added to the sense of isolation and prevented networking opportunities. This was worse for women off campus. The sense of isolation is exacerbated when women are sometimes the only female in meetings. It was felt that the systems excluded women, they do not have the chance to get to know people and this would be useful for writing purposes. These social barriers do not affect males in the same way. There appeared to be a lack of respect for females in a male dominated environment. [...] Other concerns included the lack of mentoring opportunities, the lack of women at the top, not enough role models, resulting in no sisterhood. It was much easier for men for mentoring – probably because of the 'old boys' network'. The group would not recommend a career in science as there is no defined career path, it is not family friendly and it is difficult to get a permanent job. PDs are very competitive, but there are not enough academic positions on offer, and women with families and mortgages especially, get 'comfy' and find it hard to move. Opportunities for industry experience are lacking. Different approaches by different departments to PDs are being experienced. On the whole, the UCC does not encourage teaching by PDs. Although academics are overworked, departments will not pay or allow PDs to teach for academic experience. More formalised procedures are needed when supervising students. Although PDs are active researchers, they are not involved in discussions with industry partners, and/or funding agencies – this makes them feel undervalued. There were a number of areas where information appears sparse, namely maternity benefits, and health and safety. Policies that are in place are not being effectively implemented. There is a lack of training in health and safety, lecturing, teaching, and grant writing. In-house training is not available to PDs, as they are not staff' (p. 10).

Galligan, Y. 2005, *Assessment of the Participation of Women in Science, Engineering and Technology at UCC*, University College Cork. Downloaded on 3/2/2010, available at: <http://www.ucc.ie/wiset/documents/UCC%20WiSET%20Report%20-%20edited%20version.pdf>

with young children and women who do not collaborate in research with other scientists are less productive than both their male and female colleagues. Ledin et al. (2007) found slight gender differences in scientific productivity among applicants to EMBO fellowships that were explained by family-related time and mobility constraints. Although productivity differences were slight, the female success rate for EMBO fellowships turned out to be 20% lower than that of men. This strand of research suggests that time and mobility constraints may be relevant in terms of scientific performance in the early stages of the academic career – ‘the rush hour’: according to the logic of cumulative advantage/disadvantage, slight differences at early stages may turn into wide differences in the allocation of opportunities for doing research and have a determining impact on career outcomes. This appears to be the main conclusion of Manson and Gulden (2004). They carried out a longitudinal study in order to analyse the long-term impact of the family on the scientific careers of men and women in the US. Using data from the surveys of doctorate recipients for the years from 1973 to 1999, they analysed the trajectories of men and women twenty years after obtaining their PhD. The overall findings show that the period up to five years after obtaining the PhD is the most important for obtaining scientific recognition. Women without children or who had postponed motherhood to later years received tenure earlier. Men with a family, on the contrary, received tenure earlier.

2.3 Career advancement in academia

Structural barriers related to time and mobility constraints might be seen as indirect forms of gender discrimination and, indeed, this is the prevailing view of a certain strand of the

literature. However, the studies revised in the previous chapter indicate clearly that supply-side explanations such as motherhood or lower productivity cannot fully explain differential career outcomes for men and women in academia. Overall, ‘the way women are or behave in comparison with men is believed to have been overestimated in past research, whilst insufficient attention has been paid to the way academic institutions are and behave’ (Wissenschaftsrat, 2007, p. 20; quoted in Bettio & Verashchagina, 2009, p. 6). In this chapter we review the strand of the literature that deals with career advancement and gender discrimination practices, on the basis of the reports on science as a labour activity (Caprile & Vallès, 2010) and gender and scientific excellence (Addis, 2010).

As in other professional fields, the academic ladder is a hierarchy of power, recognition and income and gender segregation is not only the result of women’s time and mobility constraints. Other forms of gender discrimination are at play, although they usually remain hidden beneath the veil of the meritocratic ethos that prevails in academic institutions. Current research at the national level provides well-grounded empirical evidence of this fact, in spite of cross-country differences in the presence of women, the organisation of science and the structure of universities and other academic institutions: among others, Bagilhole and Goode (2001) in the UK; Beaufaÿs and Kraus (2005) in Germany; Etzkowitz et al. (2000) in the US; Gschwandtner et al. (2002) in Austria; Husu (2001) in Finland; Palomba (2000) in Italy; Šaldová (2007) in the Czech Republic or Ural (2001) in Turkey.

It is precisely the contradiction between the ideal values of science and academic practices that is the starting point of this strand of the literature. To examine this, the research goes beyond the universalistic criteria and strict norms that govern the formal procedures of recruitment and promotion in academia,

analysing power relations, gate-keeping practices and informal networks as a source of tacit knowledge, support and recognition. In general, bureaucracy is said to enhance the advancement of women, as rules correct potential gender discrimination in hiring and promotion decisions (Reskin, 1977; Reskin & McBrier, 2000). However, it is also known that instituting more bureaucratic rules and levels of hierarchy may increase the power and salience of informal, hidden modes of operation (Dalton, 1959; Gouldner, 1954). Men's homosociability –the bonding of men– contributes to their maintenance of power (Kanter, 1977). When the hierarchy is male-dominated, as in academia, bureaucratisation may fail to counteract gender discriminatory practices.

Research perspectives are diverse. Some studies adopt Bourdieu's approach in order to understand academic science as a social field: 'The 'pure' universe of even the 'purest' science is a social field like any other, with its distribution of power and its monopolies, its struggles and strategies, interests and profits, but it is a field in which all these invariants take on specific forms' (Bourdieu, 1999, p. 31). Others put the emphasis on the culture of academic institutions, their implicit masculine norms and values, which define particular ways of doing science that are, nevertheless, historical and contingent (Schiebinger, 1999). Some frame gender relations in terms of patriarchy (Walby, 1989), while others contend that there are different ways of doing gender (West & Zimmerman, 1987).

In spite of the multiplicity of perspectives, the literature nevertheless converges in some focal points. Academic institutions are seen as gendered institutions in which women have more difficulties than their male peers in entering the circles of academic power (Acker, 1990, 1992; Benschop & Brouns, 2003). The salience of informal male-dominated networks (old-boy networks) is highlighted

together with such a well-known concept in the sociology of science literature as gate-keeping (Merton, 1973). Gate-keepers are established scientists or peers that control the definition of merit and the means of exercising academic power. It is argued that the fact that the gate-keepers of scientific research in Europe are white, middle-aged male academics restricts the possibilities of those individuals that do not conform to this profile (Osborn et al., 2000). As Addis and Brouns (2004) stress, scientific excellence (the definition and assessment of merit) is not independent of gender relations in academia and society at large. Gendered inclusion/exclusion mechanisms appear thus to be embedded in the standards and cultures of academic institutions and scientific disciplines, channelled through homosocial practices into informal networks and gate-keeping processes.

Gender discrimination is seen to operate at two distinct, although closely related, levels. The first level is the lack of informal support in career advancement that leads to discouragement: from unfavourable tutoring and mentoring relations and the lack of collegial relationships with peers, to a hostile work climate and sexual harassment. As Husu (2005) stresses, gender discrimination in academia may take different forms, sometimes overt, but most often subtle and hidden: recruitment to attractive temporary positions can take place unannounced and behind closed doors, which is favourable to an exclusive group of men; invitations to women can be 'forgotten' when there is a place as a keynote speaker at a conference. What is happening may really be that 'nothing happens' or that something that should take place in the career does not happen: not being seen, heard, read, cited, invited, encouraged. Consisting of non-occurrences, this kind of discrimination is hard to identify and challenge. The second level refers to bias in formal assessment procedures that leads to unequal

Box 22. Understanding scientific excellence

The definition of scientific excellence is elusive. The scientific community acts as if excellence were an obvious quality, and seldom feels the need to define it clearly. According to the documents written by professionals and agencies whose mission is to foster scientific excellence, it can be defined as follows:

Scientific excellence is the ability of a scientist or an institution to impact on a field of study producing a major change, leading other scientists towards asking new questions and producing new, important and useful contributions to knowledge, using new methodologies. The quality of excellence must be proven by a number of means, (such as publications, citations, funding, and students) and recognized by the peers by the bestowing of various honours, prizes and other awards.

The scientific community seems to act as if the meaning of scientific excellence were obvious and agreed on by all participants of the scientific enterprise. It behaves as if scientific excellence were an uncontested terrain and the procedures and criteria that lead to the selection of the top layer of scientists who are considered excellent were given, known, and unproblematic. However, contributions in the literature (Addis & Brouns, 2004) underline the need to engage in a critical reflection on the concept of excellence as well as on the processes and procedures that lead to the creation and recognition of excellence. Excellence is the final result of procedures that place scientists and scientific institutions in different positions within the network and the hierarchy of their fields. The fact that women scientists do not achieve excellence at the same rate as would be predicted by their results in the earlier stages of their scientific career is the product of a number of social processes within and outside the scientific community.

A correct understanding of excellence and of the processes whereby excellence may be achieved is essential in order to develop effective policies. If we identify excellence with the existing top layer of the academic hierarchy and design policies allocating resources mainly to this top layer, then the quest for scientific excellence may boomerang, slowing down women's integration into science. The quest for excellence should not be used to perpetuate old mechanisms of cronyism, lack of transparency in cooptation mechanisms, and gatekeeping that systematically favours male homosociability. This would prevent the achievement of excellence by the European scientific community as a whole. If, instead, the quest for excellence is interpreted correctly as a process that should be free of gender biases and if the requirements of excellence are defined in such a way as to encompass the different lives of men and women, such a policy would be able to tap misused intellectual resources of many potentially excellent women scientists in Europe.

Addis, E. 2010, *Gender and scientific excellence. Meta-analysis of gender and science research – Topic report*. Downloaded on 16/11/2010, available at:

http://www.genderandscience.org/doc/TR5_Excellence.pdf

access to research funding or academic positions. Here, again, research shows the subtle ways in which discrimination may operate. From the unconscious use of gender-based double standards in highly formalised and seemingly gender-neutral peer-review processes in the early stages of the academic career, to more explicit bias where access to higher positions or awards is concerned and non-transparent cooptation procedures prevail.

Rositter (1993) coined the term 'Mathilda effect' to highlight the fact that gender discriminatory practices follow the same logic of cumulative advantages and disadvantages already explained by Morton's 'Mathew effect'. The Matthew effect refers to the social processes through which initial advantages in terms of capacity, structural location and available resources make for successive increments in advantage such that the opportunities for undertaking scientific research and receiving symbolic and material rewards for its results tend to accumulate for some scientists and scientific organisations (Merton, 1968, 1988). Following the same cumulative pattern,

women's slight disadvantages in the early stages of the scientific career might turn into wide differences in career outcomes. In *Why So Slow? The Advancement of Women*, Valian (1999) contends that a continuous accumulation of small advantages for men and small disadvantages for women operate insidiously, resulting in very different career opportunities for the sexes.

Evidence of gender discrimination casts doubt on the myth of individual merit in science. Most research in the field shows the problem through the lens of 'patriarchy', highlighting the contradiction between the myth of individual merit and the reality of a patriarchal support system (Bagilhole & Goode, 2001). As these authors contend, the 'central argument is that, in terms of academic careers, individualism is the myth while male support systems are the reality, in the process disadvantaging women who do not take to the former and are excluded by definition from the latter' (p. 161). 'This perpetuates an in-built conservatism where those who emerge via such processes are very likely to be another

Box 23. The Matthew effect in science

The Matthew effect consists of the accruing of greater increments of recognition for particular scientific contributions with respect to scientists of considerable repute and the withholding of such recognition from scientists who have not yet made their mark.

As originally identified, the Matthew effect was constructed in terms of enhancement of the position of already eminent scientists who are given disproportionate credit in cases of collaboration or of independent multiple discoveries.

The Matthew effect may serve to heighten the visibility of contributions to science by scientists of acknowledged standing and to reduce the visibility of contributions by authors who are less well known.

A macrosocial version of the Matthew principle is apparently involved in those processes of social selection that currently lead to the concentration of scientific resources and talent.

Merton, R.K. 1968, 'The Matthew Effect in Science', *Science*, vol.159, no. 3810, pp. 56-63.

one of the 'guys' (p. 171). For those men who find themselves in influential company, this process of networking, mentoring and sponsorship need not necessarily be a conscious activity. This gives men a way of learning the tacit, implicit, indeterminate skills of a profession, while active requests for 'support' from minority groups are often interpreted in deficit terms. A substantial bulk of the research adopts Bourdieu's concept of 'habitus' to frame the problem. It is argued that scientific activity is subjectively interiorised through a set of specific schemes of perception, feeling, thought and action that structure scientific performance. This scientific lifestyle has developed historically under male domination and creates subtle 'gender borders' which women cannot easily cross. Several studies build on this approach to analyse gender inequalities in science empirically: among others, Engler (1993) in electrical and mechanical engineering; Frank (1990) in biology and psychology; Gomard and Reisby (2001) in philology and chemistry; Könekamp (2006) in chemistry and engineering and Rogg (2001) in social sciences.

Other studies put more emphasis on diversity and the current changes in the ways of doing science and doing gender. Hasse and Trentemøller (2008) highlight the extent of the variation within scientific cultures and the related tensions between traditional and more egalitarian gender relations, looking at the impacts on the life of and academic careers of both men and women. A recurrent theme is the drastic change that scientific practice is experiencing and the obsolescence of individualistic criteria when science is increasingly complex and collective. From this point of view, it is argued that scientists of both sexes would benefit from systems of recruitment, assessment and promotion that took this collective dimension more properly into account. Criticism of the highly hierarchical and individualistic university system in Germany (Beaufaj's & Krais, 2005), or the

obsolete and individualistic rules for assessment and promotion in the French CNRS (Cheveigné, 2009) are examples of studies that point in that direction. More or less implicit in this strand of the literature is the acknowledgment of a certain de-gendering process in academic institutions and scientific practices.

2.3.1 Lack of support

Informal networks are a pivotal source of support for career advancement in science. They provide the feeling of belonging to the scientific community, access to professional resources, opportunities for advancement and encouragement. Researchers are in agreement that women's poorer networking resources is a powerful, albeit subtle, explanatory mechanism for understanding women's greater attrition rate and slower career progression compared to men's. It works through an accumulative logic of 'non-occurrences' and slight exclusionary practices that progressively disadvantage women's careers and lead to a sensation of isolation, difficulty in assuming the risks inherent to the scientific career and low professional self-esteem.

Etzkowitz et al. (2000) build on this approach to analyse gender segregation in US universities. Their point of departure is that 'formal positions are only a rough indicator of success, since individuals of the same rank differ widely in the strength of their networks and their access to scientists with relevant knowledge for possible collaboration' (p. 124). Networking resources are considered to play a key role in career advancement: they allow for exchanging contacts, knowledge and information; for improving the amount, speed and veracity of the information to which one has access, for enabling and facilitating the social support essential in maintaining motivation regards scientific activity and for

being able to accept criticism at work. Networking in academia is seen to follow a pattern of social relations in which power spreads in concentric circles through a snowball process: those placed more centrally are those who accumulate more networking resources and have the capacity to generate more social capital in their connections with others. When people initially manage to extend their social capital, the probability of future inclusions increases exponentially. In the same way, a lack of initial connections in the early stages puts people at a disadvantage for the rest of their professional career. It is from this perspective that differences in the social capital between men and women in US universities are extensively analysed.

Their study is based on the empirical analysis of professional relationships and networks in a sample of university departments belonging to different scientific fields (biology, chemistry, physics, computer science and electrical engineering). The quality of the professional relationships is assessed through two dimensions, collegueship and reciprocation. The first dimension, collegueship, deals with the scientist's sense of inclusion, the enactment of a positive professional identity which is conferred through social support relationships with other members of the department. Reciprocation affects the scientist's ability to access and exchange tangible professional resources and is analysed through indicators that show the extent to which exchange relationships are unequal and reflect power imbalances. According to the authors' study, untenured women have less collegueship (less social support) than their untenured male colleagues, and women, regardless of their status, tend towards less reciprocation than men (more unequal relations), which limits their ability to obtain the necessary resources to have a successful scientific career. According to this study, these dynamics are still more pronounced in those departments in which the proportion

of women is very low and women tend to have a 'token' status. A critical mass of women (more than 15% of faculty members) may be one factor that can overcome the barriers against women's success, but would not solve all the problems.

The study also looks at the quality of professional networks and distinguishes between two types of connections: intradepartmental networks, based on strong ties within the department itself, and interdepartmental networks, which refer to the establishment of bridge bonds between different departments. Interdepartmental networks are basic for the keeping abreast of new breakthroughs, for getting important papers before they are published, for learning where researchers invest their resources, for importing techniques from other disciplines and generating channels for presenting work. The analysis shows that while men and women have similar intradepartmental networks when there is a 'critical mass' of women in the department, women's interdepartmental networks are smaller than those of their male colleagues.

Research in European countries provides a similar picture, in spite of the variety of national contexts and academic institutional settings. From a comparative perspective, it is perhaps worth noting that pervasive, albeit subtle, exclusionary practices appear to be at work even in countries considered to have reached the highest levels of gender equality inside and outside academia. As Husu (2001, 2005) stresses, Finland might be considered a paradigmatic example of the resilience of this kind of hidden discrimination. From a comparative perspective, Finnish social support systems, including good quality childcare and long maternity and parental leaves, are relatively favourable, though not unproblematic, to the combining of professional work and parenting. Women in Finland have historically had a stronger

Box 24. Academic women and hidden discrimination in Finland

Academia promises much for women. Formal obstacles regarding women's access to higher education or advancement to even the highest academic posts are rare. Women have made great gains as recipients of higher education, and in many countries over half of the student population is female. However, women's underrepresentation among academics and gender inequalities in academia are persistent and a global phenomena. This is also the case in Finland, one of the leading countries in the world when it comes to overall gender equality, and a country with the highest proportion of women in the professoriate within the European Union. This doctoral thesis approaches academia as gendered organisations, characterised by gendered divisions, symbols and interactions. It draws on over 100 semi-structured interviews and written accounts from women in eleven Finnish universities and all the main disciplinary fields. In examining academic women's gender discrimination experiences and related responses and coping, it explores how persistent gender inequalities in academia are both reproduced and challenged, in the seemingly gender equal Finnish setting. Specific issues explored include sexual harassment and motherhood in academia; academic women's support in their careers; and the survival strategies they employ. The book demonstrates how sexism and hidden discrimination continue in the daily life of academia, but also underlines the various ways academic women continue to challenge this. The book is addressed to not only academic women but all concerned with changing academia, science and society towards greater equity, increased inclusion and the full valuation of women in the production of knowledge.

Husu, L. 2001, *Sexism, Support and Survival in Academia. Academic Women and Hidden Discrimination in Finland*, Social Psychological Studies 6. Department of Social Psychology. University of Helsinki, Helsinki.

presence in higher education and academia than in many other European countries. Indeed Finland, thanks to a recent organisational reform, is currently the EU country with the highest proportion of women among full professors. Yet, Husu's extensive study shows that Finnish women continue to experience various forms of gender discrimination and sexism in academia: sometimes overt, but most often covert and hidden. In many cases, discrimination operates through covert forms of 'non- occurrences' that are especially hard to challenge. Even sexual harassment, when it occurs, tends to remain hidden. The subtlety of these practices is widely confirmed by qualitative research on women's perceptions in academia. As Koski and Tedre (2003) state,

gender issues seem to be simultaneously absent and present, to vanish whenever they are about to be found. Their study highlights the widespread difficulty of generalising personal and individual experiences to female experiences and of specifying the ways in which gender issues are present in the university. The perception, however, changes when these experiences are dealt with collectively, as discrimination is more easily identified in other colleagues' stories than in one's own. A large amount of the literature explores subtle gender borders in everyday academic life and discourses, especially local/institutional level studies which address covert discriminatory practices against women and the strategies women adopt to cope, assimilate

or rebel (e.g. Benckert & Staberg, 2001; Bondestam, 2004; Gomard, 2002; Højgaard, 2003; Knights & Richards, 2003; Mählick 2003; Maragoudaki, 2009; Sagebiel, 2010, Søndergaard, 2002). Furthermore, the lack of support and direct encouragement is seen as one of the relevant factors explaining women's lower propensity to apply for promotion and research funding (Lange 1988, Husu 2004, Leemann & Stutz, 2008).

Although research in this field tends to be fragmentary, with small-scale qualitative studies that focus on a variety of discriminatory practices in a particular institution, the review of the literature indicates three themes that have received special attention. A great bulk of the literature focuses on the early stages of the academic career, particularly PhD supervision and mentoring. A second strand deals with the subtle forms of exclusion and

inclusion in the allocation of opportunities, resources and tasks in the intermediate academic stage, such as the tendency to find more women in teaching and administrative tasks. Finally, there is another strand of the literature that explores from a more general point of view issues related to the unfriendliness of the work climate, in which the analysis of sexual harassment emerges as a distinct theme.

Mentoring

Here we understand mentoring relations in their widest sense, considering a mentor to be some senior scientist to whom PhD students or junior scientists can turn for advice and encouragement. Support is particularly important during the PhD and post-doctoral stages, the time for career formation and integration within the scientific community.

Box 25. Ambitions without a chance. Gender differences in expectations, ambitions and career efforts of PhD students at the University of Amsterdam

This article answers the question about the extent to which male and female PhD students differ in their expectations, ambitions and career efforts, and, to what extent these differences can be explained by characteristics, either individual or of the academic organisation. We answer these questions with research data that has been collected since 1999 among PhD students at the University of Amsterdam. The results show that there are enormous differences in expectations, small differences in ambitions and no differences in male and female PhD students' career efforts. Furthermore, the research results indicate that the importance that PhD students give to a private life, especially a preference for part-time work, compete with the efforts that are considered necessary for an ambitious academic career. Finally, three characteristics of an organisation affect the efforts that PhD students want to make for their academic career. Support of their supervisors, having a formal PhD contract and there being a larger number of female full professors increase the efforts that PhD students want to make regarding their scientific job. Their supervisors' support has proved to be the only factor that affects their expectations of becoming a full professor.

Need, A., Visser, J. & Fischer, A. 2001, 'Kansloze ambities? Sekseverschillen in verwachtingen, ambities en loopbaaninspanningen van promovendi aan de Universiteit van Amsterdam', *Tijdschrift voor Arbeidsvraagstukken*, vol. 17, no. 4, pp. 350-364.

Direct support from the PhD advisor or mentor and a supportive departmental climate are important factors in the reduction of both dissatisfaction and emotional exhaustion during these years of intensive dedication and uncertainty about career prospects, in which the coincidence with childbearing years is an additional source of strain for women. It is also a well documented fact that more women than men leave academia during this period, although the proportion of women among PhD students, PhD holders and post-doctoral researchers has been growing more or less steadily in most countries and scientific disciplines. However, women's attrition remains particularly high in the transition from post-doctoral positions to independent (tenured) positions (Blickenstaff, 2005; ESF, 2009; Martínez et al., 2007), the moment at which an academic career can be considered to be established. Need et al. (2001; see box 25 below) highlight the paradox of enormous differences in expectations, small differences in ambitions and no differences in career efforts of male and female PhD students. Their study identifies the quality of faculty-student interaction, and particularly the quality of supervision, as the most influential factor for academic expectations.

Ledin et al. (2007) provide further evidence of gender inequality in professional support to young researchers as a widespread phenomenon in European countries. Their study is based on a survey of applicants for the prestigious European Molecular Biology Organisation's (EMBO) Long-Term Fellowships (LTFs) and the Young Investigator Programme (YIP). They found that women reported having received less professional support than men: 32% of the female YIP applicants reported that they had a mentor, whereas 71% of those who did not have a mentor would have liked to have had one. For men, the situation was more balanced: 49% had a mentor and 46% wanted one. In general the survey found that more women than men felt they were in need

of better mentoring. Furthermore, women more frequently reported that their supervisors had become less supportive and more critical when they had children. A significant percentage of women (27% of female LTF applicants and 44% of female YIP applicants) also felt that men had received more support from their supervisors at the PhD and post-doctoral levels. In addition, 17% and 34% of the women at the early post-doctoral level or the independent research level, respectively, had witnessed what they felt to be negative discrimination of women, and 7% and 13%, respectively, felt that they had been discriminated against. The authors' conclusion is clearly stated: 'We fully accept that this is subjective, but if we also consider the responses of the male applicants to the programmes –2–8% of who reported having witnessed the negative discrimination of women– we feel justified in concluding that there is an element of discrimination against women, even in modern professional environments' (Ledin et al., 2007, p. 986). These findings are also consistent with US research, which provides similar evidence of young women reporting feelings of isolation and lack of support from peers, mentors or advisors and, in general, senior faculty (NAS, 2007).

The research suggests that the vulnerability of young scientists at these initial stages depends largely on the structural conditions of the academic career track. In highly insecure, dependent and individualistic systems there is more room for discretion and potential bias. This is the case of the German model of assistantship, in which one professor can 'make or break an academic career', as Roloff (2001, p. 6) states. Beaufaÿs and Kraiss (2005) have analysed this issue and its consequences extensively in terms of gender equality. They contend that there are four distinct major trends that make it particularly difficult to take up a scientific career in Germany. First, there is only one career model, the university model. The scientific system

does not provide the opportunity to follow other scientific paths: the directors of research in the public research institutes tend to be university professors and young scientists have to be trained and acquire their academic degrees (PhD and habilitation) at the university. Secondly, there is a general rule against internal appointments at the university. Young scientists cannot apply for a position in the same university in which their academic degree has been obtained. Third, there is not a proper university ladder with a series of intermediate tenure-track positions. The first secure position at the university is that of the professorial chair. While professors enjoy a high degree of power and scientific independence, junior scientists are forced to remain in a highly insecure situation for a long time. Their opportunities for scientific research and career advancement are strongly dependent on the professor to whom they are attached. Finally, career prospects are extremely unpredictable, and not only because the number of professorial chairs is reduced. Criteria for appointment remain largely obscure and the whole system depends on cooptation. In this kind of all-or-nothing game in which luck plays its role, gaining the favour of the professor to build a powerful set of connections remains the most effective strategy. Young women face more difficulties than their male colleagues in surviving in such a system, and there is overwhelming empirical evidence that maternity and the family are not the root of the problem. Women face without doubt more acute time and mobility constraints that play a role in cooling out processes, but dedication plays a highly symbolical role and women are first seen as female and potential mothers rather than as committed scientists. The fact remains that women are and feel less supported and encouraged to take up an academic career.

Aside from institutional constraints, other studies analyse the extent to which disciplinary cultures generate specific modes of gender

relations or gender imbalance in terms of the recruitment of young scientists (e.g. Leicht-Scholten, 2008; Lützen & Larsen, 2005; Yair, 2009). In general the research highlights some factors – the degree of male-domination, the differences between the natural and social sciences, or between science and technology – although studies are heterogeneous and do not provide a comprehensive picture. Interestingly, a trend that emerges in these studies is the relevance of different structural conditions in the natural and social sciences: academic life may be tougher for young scientists in social science and humanities compared to the natural sciences and medicine where working in research teams is much more common. The relevant finding is that this structural isolation may act as an unintended exclusionary mechanism for women, who tend to be under greater family-career tensions or have poorer network resources (Lützen & Larsen, 2005; Yair, 2009).

Indirect evidence of the extent of subtle forms of discouragement and exclusion towards women during these initial years is provided by the US literature. Mentoring is a relatively institutionalised practice in the US academic system, with a large number of studies evaluating its effects in terms of retention, productivity, professional satisfaction and career advancement. It is indeed a common finding in US longitudinal studies that a good mentoring relationship has a clear positive impact on the career outcomes of women and minority groups, with this effect in men being lower or non-significant: in the case of women, satisfactory mentoring experiences are associated with lower attrition and better results in terms of publications and tenured positions (NAS 2007, 2009). In other words, formalised mentoring relationships may provide, for those who do not conform to the implicit academic 'norm' – women, minority groups – the kind of built-in support that most men get inadvertently through informal relationships.

Professional activities and institutional resources

Research highlights that the structural location of men and women differs widely, even among scientists of a similar rank. The overall trend is that women tend to be overrepresented in less prestigious institutions and less prestigious tasks, with a more peripheral location in scientific networks and less access to institutional resources for doing science. Studies in Europe highlight the gender dimension of current dualisation tendencies in the higher education system, with an increasing divide between prestigious universities involved in high-quality research and other universities mostly dedicated to teaching (see Blagojevic et al., 2003, for the analysis of the higher education system in the Eastern countries). A similar pattern is found in the extremely competitive US higher education system (Xie & Shauman, 2003).

Gender differences in professional activities and institutional resources may be a result of blatant discrimination. In the late 1990s, the Massachusetts Institute of Technology admitted to having given fewer resources and lab space to female than male scientists of equal seniority (MIT, 1999, 2002). Since then the need to guarantee equal access to institutional resources has been present in US academia and recent studies show that equality prevails among scientists in the same institution and similar position (NAS, 2009).

Our review of the literature shows that this concern is not present in European studies. However, great attention has been paid to the kind of academic tasks that men and women perform. The unequal distribution of academic tasks between men and women is a sensitive question because promotion criteria are usually based on research outcomes, albeit teaching and administrative tasks may require substantial energy and time. The

Box 26. Women scientists perceptions of their work conditions and career development

This article reports preliminary findings on Portuguese women scientists' perceptions of gender issues in their institutions. Empirical data were collected by means of an electronic open questionnaire sent to the members of AMONET (Portuguese Association of Women in Science). Basically, the study aims to examine the degree of satisfaction with their profession, the difficulties they meet in everyday professional life, and whether they feel or have ever felt gender discrimination in their institutions. Findings show that all respondents feel happy or very happy with their profession. However, discrimination is mentioned by a significant percentage, even if such discrimination quite often assumes an elusive form, suggesting that higher institutions still discriminate against women. The findings, articulated in the literature, also lead to discussion about power and leadership, both in the hands of male academics in the majority of the institutions, as well as to the clarification of the different male and female perceptions of ambition.

Gonçalves, M. 2006, *Scientist women perceptions of their work conditions and career development*, Universidade Nova de Lisboa, Faculdade de Ciências e Tecnologia, Unidade de Investigação, Educação e Desenvolvimento, Caparica, vol. 7, pp. 147-155.

general assumption is that women tend to dedicate less time to research and more to teaching than their male colleagues, although this pattern cannot be generalised. This is one of the issues considered in diagnostic studies linked to gender equality programmes that have been instituted in a series of European universities during the last decade. For example, Izquierdo et al. (2004) analyse in detail the allocation of tasks at one of the most important universities in Spain, finding that women tend to dedicate more time to teaching and other 'invisible' and poorly recognised tasks than men of similar rank. In Germany, gender differences in the teaching workload among PhD students and post-doctoral researchers have long been considered one of the factors that disadvantages and discourages women (Mersmann, 1996; Roloff, 2001), although research shows that such differences are decreasing (Lind, 2006). A recent US study concludes that the situation varies across disciplines: in some fields (biology, civil engineering, electricity and physics), the amount of time dedicated to research, teaching and other services is similar for male and female scientists of similar rank, while in others (chemistry and mathematics) it has indeed been confirmed that men dedicate more time to research than women (NAS, 2009).

In general, the literature stresses that eventual gender differences in the allocation of time to research, teaching and administrative tasks have important consequences for career advancement. However, it is also worth noting that research in this field provides other relevant reflections. Women, precisely because they are victims of the contradictions inherent to the academic system more frequently than men, appear to be more aware of the tensions related to the fact that academic institutions do not fully foster and recognise research cooperation and non-teaching activities. This is the main conclusion of the study by Cheveigné (2009) on gender

inequalities in the CNRS. Attention to the collective dimensions of research is the main specificity in women's discourse that differentiates it from that of men: 'The women we interviewed at all levels of the hierarchy chose to privilege the collective dimension in a very explicit way: they subscribed less readily than did men to the value of idealized isolation for the researcher, and they spent a lot of energy attempting to palliate objective isolation and to ensure collaborations at all levels, whereas their male colleagues readily adopted more individual strategies. However, in spite of official statements to the contrary, promotions both for researchers and support staff are mainly based on individual accomplishments or activities. In allowing such a situation to go on, the organization reinforces the observed contradictions, especially to the detriment of women. It confirms an individualistic model through the way it considers some types of activity. At the same time it makes collective work both more necessary and more difficult through the way it imposes excessively complex organizational requirements on its employees. Thus, it validates traditional gender relations in science, instead of seriously counteracting them' (Cheveigné, 2009, p. 130).

Sexual harassment

Studies on the work climate in academic institutions tend to highlight that a male-dominated environment can be hostile to women in several ways, from difficulties in socialising with male colleagues to bullying and sexist attitudes. The most blatant is sexual harassment, a particularly delicate matter. The US literature has paid considerable attention to this theme (e.g. Paludi & Barickman, 1991; Patai, 1998) but according to our review there has been no systematic research in Europe. However, the existence of sexual harassment has been documented in a number of studies and it is worth noting

that in countries such as Finland and Sweden research on this theme appears to have been encouraged by greater sensitivity on the part of academic institutions and equality policies. In spite of this, all the studies provide a common picture of the difficulties in counteracting a phenomenon that tends to remain hidden and leads to the isolation of the victim.

A study at the University of Helsinki showed the pervasiveness of this problem (Mankkinen, 1995). During the previous two years, about 7% of the university staff had suffered sexual harassment, 78% of whom were women. Of the students, almost 3% had been victims, the majority of whom were also women. The study confirmed that sexual harassment may

Box 27. Support, encouragement and recognition in men and women's academic careers. Results from the Athena Survey

The Athena Forum's mission is to provide a strategic overview of developments that seek to, or have proven to, advance the career progression and representation of women in science, technology, engineering, mathematics and medicine (STEMM) in UK higher education. Forum members are nominated by the UK's leading scientific professional and learned societies. One of its activities is to carry out surveys regularly on the differences, both real and perceived, between men and women's career progression in UK universities. The 2007 Forum report presents the findings of the 2003/04 and 2006 surveys. The 2003/04 survey covered 40 universities and 4,282 respondents (F 1,535, M 2,747). The 2006 survey covered more than 70 universities and 3,453 respondents (F 2,288, M 1,165). Results point to the institutional processes where changes could make a difference. They suggest that much still needs to happen before women perceive themselves to have the same level of support, encouragement, development opportunities, and recognition as their male colleagues:

Key career transitions- promotion

- Women are less likely than men to be encouraged to apply for promotion.
- Women are less aware of promotion criteria and processes.

Career development

Career development provision

- The higher the grade, the more likely it is to be provided by employers.
- Women are less likely than men to have employer provision, and more likely to look for it in their professional societies.

Factors contributing to career progression

- Women are more likely than men to rate the following as important: external collaborative work, external networking and support/encouragement from their partner/family.

Professional activities

- At the professorial level women are as likely/more likely to be invited to contribute to conferences, however, at lecturer level women are overlooked.

Organisation and culture of STEMM departments

- At the professorial level women are much less likely than men to head departments, but do carry at least a fair share of all other administrative/management roles.
- Men feel themselves to be 'better treated/better supported' by their departments.
- Women feel their 'disadvantage' far more strongly than do their male colleagues, in particular in relation to promotion and visibility in senior management.

Flexibility in the working day, working year and working life

- Over half the female professors and senior lecturers in the 2006 survey had taken career breaks.
- For women who had taken career breaks, good quality child care and flexible working were the most important factors for returning to work.
- Flexible working was valued highly by men and women
- At senior lecturer level significantly more women than men rated as important, meetings finishing on time/being held in core time.

Athena Forum 2007, *Athena Surveys of Science Engineering and Technology (ASSET). Headline Findings on Women's Career Progression and Representation in Academic Science from the 2003/04 and 2006 Surveys*. Downloaded on 13/04/2010, available at:

http://www.athenaforum.org.uk/reports/Report2AthenaASSETGuide_revised_styled.pdf

take multiple and diverse forms, from serious harassment to the overemphasising of sexual roles, or ambivalent disturbance on the part of a colleague or a student. In turn, it could be a single harsh incident or a more continuous process, in some cases accompanied by promises of career advancement. It was found that sexual harassment provokes a deep feeling of isolation and professional discouragement. The study highlighted the veil of silence that most often surrounds such practices. Usually the victims evaded the harasser and did not talk about the incident publicly. Starting action against this person was difficult, due to the shame of the victim or institutional practices and traditions of covering such incidents up. In a similar vein, Bagilhole and Woodward (1995) contend that the incidence of sexual harassment in UK universities is underestimated, as well as its impact on women's professional careers. On the basis of a qualitative study in a UK university, they conceptualised the different types of sexual

harassment that exist in universities, both among students and among teaching staff, constructing a gradation that ranges from verbal intimidation right through to physical assault.

The ambiguity that surrounds the very understanding of sexual harassment has been explored by Carstensen (2005) in Swedish academia. The study argues that the use of this concept is partly informed by the assumed gender neutrality of the professional order and partly by what are culturally expected interactions between men and women. However, the space for drawing a boundary and naming some type of behaviour sexual harassment seems to be minimal. Harassment tends to become 'everything' and 'nothing' at the same time, with this ambiguity paving the way for the invalidation of sexual harassment as a real problem in the academic setting. Similar conclusions were also drawn by Färber et al.

(1994), who analysed empirically the sexual harassment of students by professors in one German university, underlining its dramatic consequences for the students' academic careers. They argued that the topic of sexual harassment was particularly controversial in academic debates about political correctness. Supporters of a liberal atmosphere at universities blamed the women that reported harassment for being 'touchy' and all too disposed to seeing themselves as victims. It was also found to be the prevailing mood among students, with many victims having shared these opinions before being sexually harassed themselves.

2.3.2 *Double standards*

Gender discrimination may operate not only through subtle forms of isolation and discouragement, but also in formal processes of assessment that have a direct effect on the allocation of opportunities, e.g. who receives a grant or who is appointed to a certain position.

Research in this field is scarce and relatively recent. The pioneering work was that of Wennerås and Wold (1997) concerning awards of post-doctoral fellowships in biomedicine in Sweden. The evaluation procedure was apparently excellent for ensuring fairness: five committee members, who were not allowed to review candidates institutionally close to them, evaluated each dossier. As is well known, however, their study showed that the performance of men with ties to the committee members was systematically overestimated whilst that of men with no connections and women was underestimated. A female applicant had to be 2.5 times more productive than the average male applicant to receive the same score as he did. Women without connections suffered a double handicap and in order to achieve a score as high as that of one man with connections they had to demonstrate such a high level of

productivity that only three (two women and one man) of the 114 applicants attained it. 'Hence, being of the female gender and lacking personal connections was a double handicap of such severity that it could hardly be compensated for by scientific productivity alone' (Wennerås & Wold, 1997, p. 342). In order to prevent such a waste of talent, they called for a scientific evaluation of the system of scientific evaluation and the development of peer review systems with some built-in resistance to prejudice and nepotism.

As a means of avoiding any possible gender bias, the ETAN report (Osborn et al., 2000) made an explicit call to increase the transparency and accountability of the peer-review system. This recommendation, thanks to the support of the European Commission, has substantially encouraged research and debate at the European level. The report *Gender and Excellence in the Making* (Addis & Brouns, 2004) provided a first opportunity to move forward and deal with the multiplicity of factors that may bias the definition and measurement of merit across the whole academic career track. It provides a model for understanding gender bias in the definition and assessment of scientific excellence (see box 28). In turn, the report *The Gender Challenge in Research Funding* (EC, 2009b) analysed from a gender perspective the procedures used for allocating grants, fellowships and research funding in general.

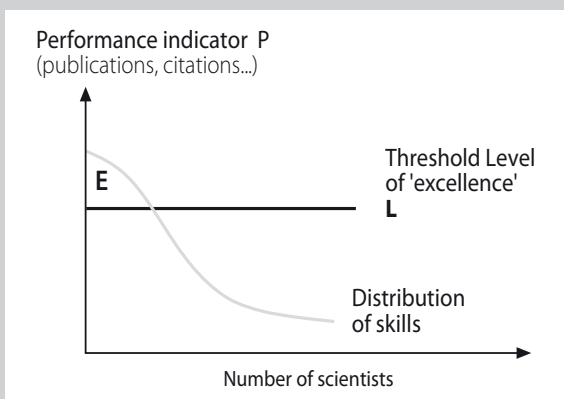
Overall, research in this field is scarce. As stressed by Meulders et al. (2010b), there is a lack of objective analysis of the practices of the different bodies and scientific committees that award research grants and funds and assess scientific excellence. Only scarce and scattered information exists on the practices of recruitment to gate-keeping positions. There is also a lack of studies on women's exclusion from relevant information and tacit knowledge that may be crucial for getting positions and research funding. The importance of so-called

Box 28. The 'threshold of selection' model: the process of excellence definition

The 'threshold of selection' model was first stated in the report Gender and Excellence (Addis & Brouns, 2004) and then revised in Addis (2008). The aim of the model is to show that there is very little that is natural and very much that is social in the process of excellence definition. Consequently, the definition of excellence can be changed so as to include women, without expecting them to live and behave as men.

The selection model is built starting from the consideration that 'excellence' to many scientists, both male and female, appears as a fairly simple concept, presumably corresponding to an objective and easily measurable variable. It assumes that talent is distributed among people so that some have more, some less, according to some statistical distribution. This scheme is illustrated in Graph 1 below.

Graph 1. A simple model of excellence



The number of people engaged in science is measured on the horizontal axis while performance is measured on the vertical axis by an indicator, P, such as publications or other quantifiable indicators, impact factors, H values, university of graduation, and so on. The indicator is accepted by consensus in the scientific communities and thus depends on the preferences of the gatekeepers. The curved line represents the distribution of the skills which are relevant to being a good scientist. The straight line

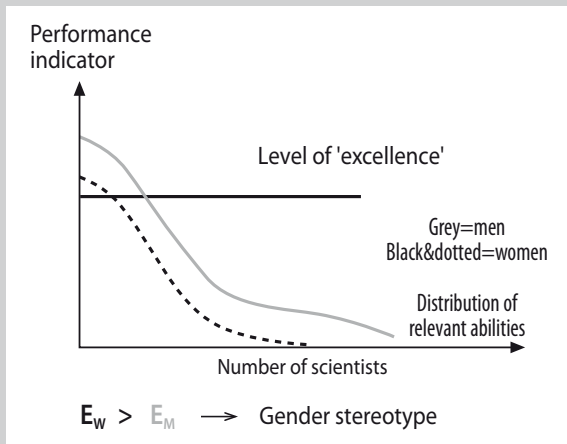
represents a given level of the indicator variable L. If P_S is the value of the indicator P, for example publications, associated to a given scientist, S, and if L_P is the threshold level of the indicator P agreed on by the scientific community as that threshold of excellence, then: $P_S > L_P \implies ES$.

In other words, when the scientist S is above the 'excellence' threshold L then that scientist is considered 'excellent', ES. The area E under the curve represents the number of publications by excellent scientists, i.e. the 'excellence' produced.

If this simple scheme were correct, the only remaining issue would be to find good indicators and agree on their merit as well as the relative weight of different indicators P. Then we would be able to compare and rank scientists, and decide who is and who is not in the 'excellent' category. But this simple version of the selection model falls apart if we bear in mind the difference in number of men and of women participating in scientific activity. If, for whatever reasons, women participate less in scientific endeavours, the situation changes, as described by Graph 2.

Graph 2. Low women's participation (high men's participation) generates stereotypes

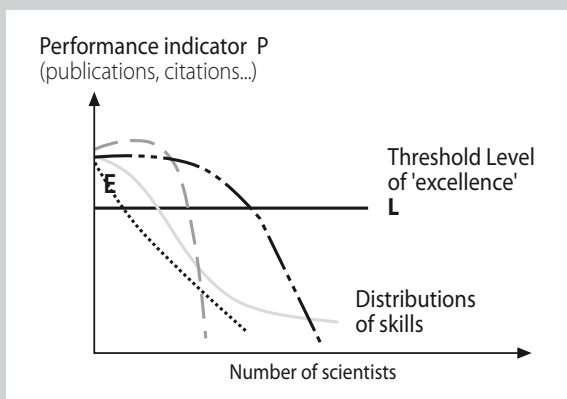
As the graph illustrates, for purely statistical reasons, even if abilities relevant to the production of excellent scientific work are distributed equally among the sexes, a low F/M ratio in the population of scientists produces a low F/M ratio among the 'excellent' scholars, implying that the number of 'excellent' men, E_M , is larger than the number of 'excellent' women E_W . What happens in consequence is stereotyping: if it is customary to find more men than women among excellent scholars, then masculinity is apt to become a sign of excellence. The stereotype that men are better than women at doing science is born.



A further question raised in this model is the appropriateness of indicators. Indicators are estimates of a true skill, which can be measured only by its outputs. What skills are measured by the curve in graphs 1 and 2? Presumably, abilities relevant to producing the indicator of excellence P. Each different P (publications, journal of the publications, university of graduation, and so on) is the result of the application of more skills than one. In the case of publications, for example, many characteristics of a human being contribute to producing publishable work: ability to write, numeracy, knowledge of the subject matter, original thinking, choosing a 'hot' topic, and so forth. Different observers may disagree on which of these characteristics is more relevant. Some believe that originality is more important than precision, others believe it is the other way round. It is important to remember that we cannot measure the skills and their distribution directly. All we can measure is the distribution of the performance indicators and assume that the distribution of the skills is the same as the distribution of the indicator. By definition, a good indicator is one distributed in exactly the same way as the skill we are interested in, but no indicator is the skill itself.

Graph 3. Which skill are we looking for?

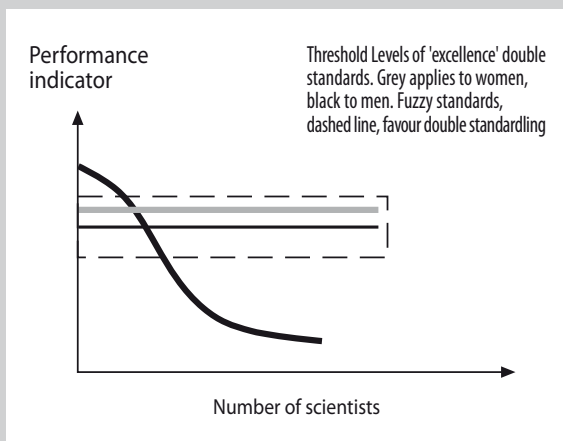
As shown in graph 3, the level indicated by the black threshold (e.g., number of publications)



may be obtained using different amounts of different skills (yellow and dotted line, precision; green and slashed line, originality; blue and dotted and slashed line, depths of knowledge, and so on), each with its own distribution. The line that represents the distribution of abilities in the simplistic model, therefore, does not exist per se: it is the aggregate of many different skills and as an aggregate, it represents only the skill to produce the indicator P.

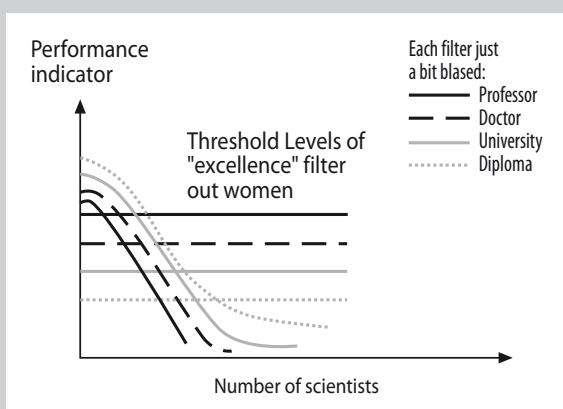
The aim of the selection process is to screen for people able to produce new and useful knowledge, but it is not always self-evident what is new or what is useful. Who decides what is new, and who decides what is useful? Gatekeepers are powerful because they are in charge of defining what is new and useful. If there are subjective elements in judging, the implication is that different gatekeepers may favour different skills and different indicators. Therefore, who the gatekeepers are is of utmost relevance. It is not true that anyone in the position of judge would make the same choice regarding who is excellent. Selection for excellence is not a neutral, natural process that always gives the same result, like a chemical reaction. It is a social process that involves power for some to accomplish what they want to do – provide answers to some questions – while others are denied the same power. It is a political process: to decide who gets what.

Graph 4. Fuzzy standards may help discrimination



Graph 4 illustrates two more mechanisms whereby women are prevented from achieving excellence: double standards and fuzzy standards. There is evidence of the fact that the standard applied to men and women is not the same: the standard applied to women to qualify as excellent is higher. This fact is known in the literature as 'double standard'. It is easier to apply a double standard if the standard is fuzzy, i.e., unclear to those in charge of the judgment and unclear to those who should pass the standard.

Graph 5. Cumulative effects of a small bias



In the selection model, cumulative effects are at work. The level of excellence is only the last of a series of subsequent applications of a standard, determined by the gatekeepers over a population of applicants. If there is a small bias against one group in each subsequent application, the effect snowballs: members of that group will become proportionally scarcer and scarcer on the way to the top. The cumulative effect of small biases is described in Graph 5.

Addis, E. 2010, *Gender and scientific excellence. Meta-analysis of gender and science research – Topic report*. Downloaded on 16/11/2010, available at:

http://www.genderandscience.org/doc/TR5_Excellence.pdf

men's networks should also be further analysed. The analysis of gender differences in promotion and research funding is not just a question of whether allocation practices are gender biased, but also of the ways in which institutions are complicit with the inequalities that have marked the academic trajectories of applicants. For example, research on the gender composition of and task distribution within the editorial boards of Italian economics journals has shown that women scientists are on average underrepresented on these boards, even with respect to the top echelons of their field, and that role allocation is heavily gendered, i.e. men are mostly appointed to honorific positions and women to do the editorial work (Addis & Villa, 2003).

At best, research in this field is very recent and has been parallel to a process of increased formalisation of systems of evaluation in most Western countries, itself part of a broader emphasis on transparency and accountability in the whole academic system. However, formalisation remains at odds with access to the scientific elite, in which procedures for recognition are far less transparent and criteria more diffuse and intangible. Both themes emerge in the literature review. Whilst research has started to pay a certain amount of attention to assessment criteria and peer review processes in the early stages of the academic career, the more opaque procedures of cooptation in the scientific elite remain largely under-researched.

Formalised peer review processes

It is a well documented fact in psychosocial research that gender does matter in evaluation procedures. In spite of a general move towards more equal gender relations and values, the majority of both men and women tend unconsciously to rate the

quality of men's work higher than that of women when they are aware of the sex of the person to be evaluated, but not when the sex is unknown. Evaluation experiments show that changing the submitter's first name results in a significant difference in the scores assigned to identical documents (Steinpreis et al., 1999). Experiments conducted by Foschi (2000) show the pervasive, albeit unconscious, use of gender-based double standards, with stricter standards for women than for men. That the peer-review system is vulnerable to this kind of prejudice was first shown by Wennerås and Wold (1997). A metaanalysis of 21 studies showed that men have a statistically significant (7%) higher chance of receiving grants than women (Bornmann, 2007; Bornmann et al., 2007). Overall, the literature contends that differences in men's and women's success rates require further scrutiny. Of particular concern are grant and fellowship programmes for young researchers with huge gender differences in success rates, because it does not seem plausible to find large differences in scientific performance at such early stages (de Pablo, 2006; Watson et al., 2005).

In the Netherlands, Brouns (2000) conducted a similar study to that of Wennerås and Wold, also of post-doctoral fellowships. The study analysed gender bias in assessment procedures in one of the major institutions for scientific grants in the Netherlands, the Dutch Organisation for Scientific Research (NWO). Two scientific fields were selected: one in which women were very successful (science and mathematics), and another in which women were not (biology). A total of 128 files were analysed on the basis of a correlation of characteristics of the applicant (sex, age and scientific productivity), assessments by the external advisors (peer review), and the final decision of the NWO. It was found that on average, women had slightly better publication scores than men, a fact that was interpreted as confirmation of more stringent self-selection processes in the case of women. Unless they

were particularly well qualified, women did not apply. Secondly, it appeared that when men and women had equally high productivity scores, women were more often characterised as ‘good researchers’ while men were described as ‘brilliant researchers’. Finally, the expected correlation between track record, peer review, and the NWO decision could only be demonstrated for the male applicants. In the case of women the connection between qualification and success was not straightforward. Women in biology were evaluated less favourably than were men with similar track records, whilst women appeared to receive preferential treatment in science and mathematics.

This study may be considered illustrative of the overall situation. It does not provide a straightforward confirmation of pervasive discrimination against women in peer-review procedures but it shows that discrimination may and does occur, as our meta-analysis of the literature has shown (Meulders et al., 2010b). The evaluation of merit is not independent of gender relations in academia and the society at large (Addis & Brouns, 2004). Ledin et al. (2007) did not find any evidence of gender bias in the allocation of the European Molecular Biology Organisation’s (EMBO) post-doctoral fellowships, in which women’s success rate is on average 20% lower than that of men. Having tested different ways in which unconscious gender prejudices may have influenced the decisions made by the selection committee, their overall conclusion was that the system was not biased. Nevertheless, it is also worth noting that the EMBO has adopted a proactive policy of transparency and gender monitoring in its selection processes for some time. The institution has fostered gender awareness among members of the selection committees with gender-disaggregated statistics available from 1996 onwards and regular monitoring of its selection processes with regard to gender. The ‘evaluation of the evaluation’ is a

powerful mechanism for preventing any potential gender bias. It is well known that the devastating results of the study of Wennerås and Wold (1997) led to a reorganisation of the peer-review procedures within the Swedish Medical Research Council. Their study was replicated some years later, with the perhaps not so surprising result that gender bias appeared to have been eliminated, while nepotism still remained (Sandström & Hällsten, 2008).

Although it is widely agreed that more transparency is needed to remove potential biases in assessment procedures, either gender-related or not, the scrutiny of peer-review systems is usually met with reticence by academic institutions. Many expert reports contend that more often than not, the analysis is simply not possible because the information about the applicants is not made public. The case of the Czech Republic is just one example among others. Although several studies have been recently carried out in order to analyse why women receive fewer awards than their proportion among scientists would justify, in-depth analysis of gender bias in assessment procedures is hindered by the lack of data: even sex-disaggregated data on applicants and awards are not made public, despite a motion from the National Centre for Women and Science (NCCWS) calling on the Research Council to do so (Křížková, 2009). Perhaps it should be remembered that the Wennerås and Wold (1997) study could only be carried out after the authors cited the Swedish law authorising access to official documents.

Another strand of research examines evaluation criteria.⁴ As Feller (2004) states, assessment procedures that rely only on bibliometric measures not only exacerbate

⁽⁴⁾ See the topic report *Gender and scientific excellence* by Elisabetta Addis for an in-depth discussion of gender bias in assessment criteria and bibliometric measures (Addis, 2010).

existing inequalities between men and women in the scientific system, but might not be the best way to assess the scientific potential of candidates. Particularly, slight differences in the number of publications at an early stage of the scientific career might turn into wide differences in the allocation of opportunities for doing research and have a determining impact on career outcomes. This is, at best, the main conclusion that can be drawn from the above-mentioned study of the EMBO fellowships (Ledin et al., 2007). Their bibliometric analysis showed that there was a small but statistically significant gender gap in the number of publications, which they explain in terms of women's greater time constraints due to traditional gender roles. Research in this field has paid special attention to the implicit norm of uninterrupted dedication that prevails in most grant schemes, with disproportionate effects for the take off of women's careers (Linková, 2002; Thorvaldsdóttir, 2004).

Research in this field also contends that the undervaluation of non-research activities is a relevant factor to be taken into account. One of the conclusions of the International Congress of Gender Bias and Inequalities in the Evaluation of Academic Quality, held in Spain in 2008, is that the assessment of the academic curriculum has been reduced practically to the consideration of publications and participation in competitive research projects, with teaching activities implicitly devalued (Izquierdo et al., 2008).

Finally, a large body of the literature highlights that the evaluation system prizes the knowledge produced by established scientists. This fact entails bias against non-mainstream research subjects and methods, which are more frequently used by women than by men due to their more peripheral situation in the scientific system (Drotner & Mouritsen, 1999; García de León, 1990; Hearn, 2001). A direct consequence is the reluctance of the scientific

community to recognise the relevance of sex and gender analysis for research, a fact that disadvantages those scientists, mostly women, who adopt this perspective (Schiebinger et al., 2010). Allmendinger and Hinz (2002) illustrate this fact in their study of gender differences among sociologists in Germany. Three key issues of the scientific career are analysed: 1) chances of publication for submitted manuscripts; 2) chances of approval for submitted project applications and 3) chances of success of applications for a professorship. Their research shows that the application behaviour of female scientists is similar to that of their male colleagues but their chances for success in all three areas are significantly lower. This inequality can be at least partially explained by the gender-specific focus of the research proposals. Half of the applications for research funding submitted by women can be categorised as gender-oriented research.

Cooptation procedures

The trend towards transparency and accountability in academic assessment procedures is aimed at counteracting the hidden power dynamics that are at play when any funding or appointment decision is made. The higher we climb in the academic hierarchy towards the elite, the more the informal power dynamics that all organisations have developed through the so-called 'invisible colleges' or 'old boys' networks'. As Palomba states (2006, p 136), 'we are still fighting to demonstrate that the low female presence at the highest levels of the scientific hierarchy is an indicator of the incapacity of research institutions to follow changes in society (such as women's increase in higher education) which in turn highlights the dysfunction of a system for the evaluation of scientific excellence that did not abolish or weaken the 'old boys' network' system' of co-optation, a system well known by those who participated in whatever procedure for

Box 29. Professional networks and gender differences in promotion

The aim of this paper is to analyse the factors that influence the length of time there is to promotion for male and female academics. Promotion is defined as elevation to a professorship. The authors examine the role of academic profiles, which are based not only on publications, but also include activities such as fund raising, consulting, teaching and managerial appointments (for instance, being dean of a department). The paper examines the factors that speed up or slow down the progress of an academic career for males and females, respectively, to explore the effects of the 'glass ceiling'. Survival and duration models are used to test whether the gender differential persists after controlling for observed and unobserved heterogeneity. The originality of this paper lies in the use of duration models to track sex differences in promotion criteria. It highlights that there are different criteria of promotion for male and female academics: women have to demonstrate higher involvement in different networks in order to be promoted.

Sabatier, M., Carrère, M. & Mangematin, V. 2006, 'Profiles of Academic Activities and Careers: Does Gender Matter? An Analysis Based on French Life Scientist CVs', *The Journal of Technology Transfer*, vol. 31, no. 3, pp. 311-324.

evaluation or selection where the antinomy between the criteria of 'being part of' (a discipline, a 'school', an academic circle, etc.) and those of merit enter inexorably into conflict, to the full advantage of the former'.

This statement is based on the results of the study on gender and science in Italy coordinated by Palomba (2000), which casts more than a few doubts on the meritocratic ideal. In the framework of this study, Menniti and Cappellaro (2000) analysed the factors influencing access to the highest scientific positions (A grade) at the National Research Council (CNR), the largest Italian public research body with a scientific staff of over 6,000. The analysis was based on a cohort of about 1,000 scientists – of whom a fifth were women – who entered the B grade in the same year. Survival analysis techniques were used to measure an individual's probability of surviving until a given event took place within a certain time interval. The 'event', in this case, was being promoted to A grade. The

study showed that men had a significantly higher probability of being promoted, other factors being held constant (age at promotion, disciplinary field and number of publications). For example, after seven years at the B grade, men had a 23% probability of being promoted to A grade, while women only had a probability of 12%. After 11 years in the B grade, men had a 28% probability of being promoted, women less than half the chance. The conclusion is that 'factors such as age at promotion, disciplinary fields and the number of publications only provide a partial explanation to the gender differences occurring in scientific career pathways. The main explanatory factor is and remains gender' (Palomba, 2006, p. 136). Similar studies have been carried out in other academic settings and countries, with similar results (e.g. Micali, 2001 for university professors in Italy or Sabatier et al., 2006, for life scientists in France). Interestingly, Sabatier et al. (2006) found that everything else being equal, women had to demonstrate a higher level of involvement in

professional networks to be promoted to the highest academic grade.

Research exploring the gender dimension of these hidden power dynamics that govern access to elite positions is scarce. A notable exception is the study of García de León (2005) about the Royal Academies of Science in Spain. The academies, which are the most prestigious scientific institutions in the country, were completely male-dominated until the late 1980s. It was not until 1987 that the first woman was appointed and ever since women have continued to be severely underrepresented, even in comparison with their presence among full professors: they are what García de León calls 'a minority within a minority'. The study is based on extensive qualitative fieldwork with both male and female members of the academies and was intended to provide greater understanding of the power relations and symbolic processes that are at play in the reproduction of male domination. Scientific excellence is understood in this study in terms of Bourdieu's concepts of habitus, social and cultural capital and distinction (Bourdieu, 1979). 'Distinction' is said to be established by the dominant social groups through cultural and social uses learnt only in a long classist enculturation process. Understanding scientific excellence through the concept of 'distinction' makes it possible to focus on the implicit and symbolic mechanisms of power reproduction in science that lead to being overly selective with regard to women. The study thus highlights that to enter these academies, women first have to pass through the same filter of scientific performance that men have to and have to achieve as much as men; then, there is the patriarchal filter, which forces them to behave like men; and third, they have to bear the burden of being singled out as pioneers in academia.

Zimmermann (2000) adopts a similar approach in analysing the appointment of professors at German universities, focusing on the hidden

power games that are at play behind the scenes. It shows how quality and decision-making criteria in appointment procedures (which are supposedly handled objectively) are negotiated, situationally modified and recodified several times. Suitability is therefore constructed as the mechanism for the persistence of male homosocial recruitment patterns that are enormously stable in higher academic positions. Already established professors negotiate the necessary qualifications for new faculty members, choose the candidates and decide whether they fit into the faculty or not or whether qualifications should be re-interpreted in order to make them suitable. The resilience of these self-perpetuating mechanisms was analysed by Vázquez-Cupeiro and Elston (2006) in Spain. Spanish universities have been recently reformed to establish a more meritocratic model of recruitment and promotion. However, the tradition of 'sistema endogámico' (an 'inbreeding' system), under which appointments are frequently made on the basis of internal (departmental) networks, persists. This was found to operate to the disadvantage of women in the two disciplines studied, psychology and engineering. In a similar vein, Van den Brink (2009) looks 'behind the scenes of sciences' to explore gender practices in the recruitment and selection of full professors in the Netherlands. The study is based on exhaustive empirical evidence, with almost 1,000 appointment reports and about 60 interviews with committee members. The research challenges the view of an academic world where the allocation of rewards and resources is governed by the normative principles of transparency and meritocracy, and highlights the distance between the ideal ethos of science and the actuality of social interaction in daily working situations. The results reveal various gender practices tied in with professorial recruitment and selection, such as the predominant recruitment by invitation, in which gatekeepers recruit new professors from their own

homogeneous male networks. Committee members appear to use micropolitics to bend the rules to their own advantage.

2.4 Scientific careers outside academia

In most European countries, statistical evidence suggests that the mobility of researchers between academia and industry basically goes one way: scientists trained in the university find a research position in industry, but returning from industry to academia is very rare, among other things, because the rigidity of academic institutions leaves little room for deviations in the academic career (ESF, 2009). Statistics also show that in most countries more women than men leave academia in the PhD or post-doctoral stages, although more men than women find a research position in industry. According to the most recent data for the EU-27, women account for 39% of researchers in the governmental sector, 37% in higher education and barely 19% in the business sector. The severe underrepresentation of women in industrial research is a common trend in all European countries, although percentages vary a great deal (EC, 2009a). Does this mean that industrial research is more hostile towards women than academic research? According to our review of the literature, the answer to this question is not so straightforward.

In this chapter we review the literature on gender and research careers outside academia. In spite of the increasing importance of industrial R&D activities, very little is known about the careers of researchers in non-academic science and technology areas (ESF, 2009). This is also true from a gender perspective. Academia is the dominant concern in the literature on gender and science, with

only few studies dealing with industry and other non-academic R&D settings.

The European Commission's initiative *Women in Industrial Research* (WiR) has played a major role in placing this issue on the political agenda. At the end of 2001, the European Commission set up an expert group to analyse and make recommendations to improve the situation of women in industrial research. The so-called WIR report (Rübsamen-Waigmann et al., 2003) stressed the underrepresentation of women in industrial research and criticised the lack of gender awareness in some companies, arguing for a general change in research cultures and working conditions which would allow men and women to have both a research career and a family life. Furthermore, under the WIR initiative a study compiling statistical data and describing good practices in companies (Meulders et al., 2003) and a survey on company level data and good practices (EC, 2003b) were commissioned. Later on, the expert group Women in Science and Technology (WiST) presented their report on the 'business perspective' (EC, 2006b), which examines what can be done to attract more women researchers into industry. A second WIST report was presented with further research on diversity management and work-life balance in all kinds of R&D institutions: universities, research institutes and companies (EC, 2009c).

These reports coincide in highlighting two main problems in industrial research that disproportionately affect women: first, a lack of structures to support a healthy work-life balance and secondly, a need to develop a more inclusive work culture in order to include more diverse researchers and enhance creativity. As stated in the WiR report: 'To promote diversity and gender balance, companies need to treat the individual as a whole person. This involves work-life balance policies that allow employees to accommodate

Box 30. Working conditions and trends for female researchers in industry in EU Member States

Based on the European Labour Force Survey (LFS) in 2002 a first analysis was undertaken to analyse the working conditions and situation of female researchers in industry. Preliminary data show the following trends:

- During recent years (1995-2000) in industry (Business Enterprise Sector – BES) employment of highly qualified female scientists and engineers increased faster than that of males.
- At the EU level, nearly 60% (in Spain, more than 80%) of all women scientists and engineers in industry/BES are under 34, they were significantly younger than their male colleagues and tended to be younger than other female employees (non-researchers) in the same sector.
- Women scientists and engineers are more likely to have a temporary contract than their male colleagues (this is even more pronounced in the public sector). However, there are significant country differences: many more women scientists and engineers have temporary contracts in industry/BES in Belgium, Italy, Luxembourg and Portugal than in other EU countries.
- A higher proportion of female than of male scientists and engineers in industry/BES is employed in small and medium-sized enterprises (SMEs).
- In all EU countries the proportion of women scientists working part-time is clearly smaller than that of other female part-time employees in the same sector. Only every sixth female scientist or engineer works part-time in the business enterprise sector. Country differences are significant: while nearly half of all women scientists and engineers in the Netherlands work part-time, only 4% do so in Denmark.
- Scientists and engineers are four times more likely to work from home than other employees, especially male scientists and engineers. While 12% of women scientists and engineers in enterprises usually or sometimes work from home, the percentage for men is 18%. Again there are distinct country differences. Nearly 50% of all female scientists and engineers in Denmark usually or sometimes work from home, while in Spain and France working from home is almost non-existent.
- In the EU, relatively fewer women (28%), who work as scientists in industry/BES, have one or more children as compared to female non-researchers working in the same sector (34%).

Rübsamen-Waigmann, H., Sohlberg, R., Rees, T., Berry, O., Bismuth, P., D'Antona, R., De Brabander, E., Haemers, G., Holmes, J., Jepsen, M. K., Leclaire, J., Mann, E., Neumann, J., Needham, R., Nielsen, N. C., Vela, C. & Winslow, D. 2003, *Women in industrial research: A wake up call for European industry*, Office for Official Publications of the European Communities, Luxembourg, p. 20.

family and caring responsibilities and, if they wish, to engage in cultural, religious, community, trade union or other activities. Secondly, there is a 'democratic' principle that entails building a listening culture, where systems and structures are transparent and open. This puts an end to patronage, the 'old boys' network' and nepotism and allows for recruitment and promotion based purely on merit' (Rübsamen-Waigmann et al., 2003, p. x).

Beyond these comparative reports, gender inequality in industrial research has not been widely studied. We have found some basically descriptive studies in a few countries, mainly providing statistics, together with other small-scale studies, especially on women in engineering, and usually exploring the situation in a specific sector and country. Comparative and large-scale empirical studies are scarce, although some relevant studies have been carried out recently. This is the case of *Prometea* for engineering (Godfroy-Genin, 2009), *Women-Core* in the field of construction-related research (www.women-core.org) or *WWW in ICT* (Valenduc et al., 2004). In addition, studies on non-academic research have been recently promoted in some countries by ministries or public institutions within the wider scope to fully address women's advancement in research-related professions (e.g. Papouschek & Pastner, 2002 in Austria). Finally, engineering professions and professional identities have been widely analysed across European countries from a gender perspective (e.g. Evetts, 1996; Faulkner, 2007a, 2007b; Marry, 2001a, 2004; Sagebiel, 2007).⁵

In spite of these limitations, the overall picture of gender inequality in industrial research appears to be quite similar to that of academia. Even those women with the best academic records have more difficulties than their male

colleagues in starting a professional career: they take longer to find a job and their employment status is more insecure (de Vicente et al., 2004). The literature identifies dynamics that are common to academia, as well as some mechanisms specific to industry, to explain the unequal situation of female researchers. The difficulties in reconciling professional and private life, unequal access to informal networks, the lack of mentoring and informal support, and the existence of stereotypes that discriminate against women in male-dominated contexts are some of the factors common to both academic and non academic settings. The distinction between structural barriers and other forms of subtle discrimination is also relevant for industry (Dainty et al., 2000; Matthies, 2005; Papouschek & Pastner, 2002). As shown in the following paragraphs, however, specific trends related to the career path, work organisation and work culture and human resource management are also relevant.

Academic versus non academic careers

Research on non academic careers highlights the fuzzy borders of science, technology and innovation. The linear model of three steps in scientific production –basic research, applied research and development– has significantly changed. Scientific development is more and more based on a more complex interaction between the university, industry and government, in which these old distinctions are significantly blurred, increasing links between academic institutions and industry develop and new science-society interface arenas emerge (Etzkowitz, 2003). Nevertheless, academic and industrial research cultures remain very different and, despite many interactions, careers are segregated. This is one of the main findings of *Prometea*, a comparative study on women's research engineering careers in academia and industry in several European

⁵ See the topic report *Stereotypes and identity* by Felizitas Sagebiel and Susana Vázquez-Cupeiro for a review of this strand of the literature (Sagebiel & Vázquez-Cupeiro, 2010).

countries: 'Academic and industrial research cultures remain very different. Despite many interactions, careers are segregated. Money and ideas circulate rather fluently: academic research is often partly financed by the private sector, and temporary jobs related to specific projects in academic laboratories may be financed by industry. On the other side, industrial research may be helped by the public sector through various instruments. We could hardly find an academic laboratory in technological research that lacked frequent communication with industry, and vice versa. However, despite continuing interactions, we observed few career changes, which is not so surprising if we consider the lack of bridges between these two cultures' (Godfroy-Genin, 2009, pp. 83-84).

Overall, the literature claims that in industry there is nothing like the rigid norms and expectations with regard to a successful scientific career that prevail in academia. Research highlights that non-academic careers do not follow a common pattern. There is huge diversity in companies and no clear patterns emerge. Work cultures and systems of recruitment and promotion vary a great deal, not only according to national contexts and research fields: they are also organisation-specific and even lab- or team-specific. This is a clear conclusion of the few large-scale empirical studies in the field (Godfroy-Genin, 2009; Valenduc et al., 2004). Papouschek and Pastner (2002) further contend that the heterogeneity of non-university research needs to be acknowledged in order to understand the diversity of gender segregation patterns.

Time and availability

In spite of their heterogeneity, non-academic careers appear to be as demanding as academic ones in terms of dedication and availability. Furthermore, in industry as in academia, career progression relies very much

on performance in the early stages, which is likely to be the period of forming a family and having children. Several studies stress that long working days, complete availability and dedication to work and the absence of flexibility for the reconciliation of professional and private lives are common trends in industrial R&D (DTI, 2005; Equalitec, DTI & Inova Consultancy, 2005; RübSamen-Waigmann et al., 2003; Wynarczyk & Renner, 2006). In many organisations, the old view of highly committed employees who can rely on private support at home still persists as the implicit assumption of an 'ideal worker' ethos that equates work commitment with uninterrupted employment and a very long working week (Gerson, 2004). This model of 'total availability' entails difficulties and disadvantages for many women and some men who need or wish to achieve a balance between work, family and leisure. Again, the requirements of dedication and availability are especially acute in the early stages of the career, forcing women in their thirties to confront a dilemma between career and family. This dilemma, in a context in which there are few flexible working practices, no role models of successful women and a certain perception of a lack of equal opportunities, is relevant for understanding the fact that more women than men leave R&D companies (EC, 2006b).

Vendramin et al. (2000) define the situation in the ICT sector as a vicious circle. ICT is not attractive to women because of the long working hours, with irregular and somewhat unpredictable schedules and the masculinisation of the sector, with a predominance of 'boundless' young male professionals with no family responsibilities. These two aspects create a vicious circle in which the 'total availability' model becomes a norm that discourages women. These trends are confirmed in the comparative study *WWW in ICT*, carried out by Valenduc et al. (2004) in several European countries (Austria, Belgium, France, Italy, Ireland, Portugal and the United

Kingdom). To characterise working conditions, they use the concept of 'blurring boundaries', which is the confusion and constant permeability between the professional and personal spheres. In the ICT sector, work is fast-paced, driven by customer demands and developed in small companies with insufficient human resource policies that exacerbate long working days and unpredictability. These conditions limit any attempts to organise a private life, the feasibility of a part-time working day and good prospects of returning after career breaks, which particularly affect women. Indeed, some studies point out that the problem is not the workload, but the lack of autonomy. Working time flexibility appears to be quite a widespread practice in ICT professions, but presenteeism remains relevant and flexibility is usually linked to longer and unsocial working schedules rather than the work-life balance. Some studies indicate that women in ICT might be willing to accept longer hours in exchange for self-management of working time (Gerwitz & Lindsey, 2000; Laufer, 2000).

Dual professional career system

A second distinct trend between industrial research and academia is the existence of a dual professional career system, with both technical and managerial career paths. As stated by a recent French study, companies do not recruit life-committed researchers: they recruit personnel with high scientific and technical skills who are expected to take charge of R&D activities, but also other tasks and, eventually, management responsibilities (MDR, 2004). In this report, three different paths are presented, with a different mixture of technical and management roles. The 'expert' path is strictly for research, built on scientific or technical progression on a certain subject. Only a minority of researchers, having obtained a certain level of expertise, adhere to it. Most of them follow the 'transversal technical' path, which entails R&D responsibilities in a

wider technical field and the supervision of other researchers, usually in the framework of a technical area or department. The third path is the 'research manager', a position only reached by a minority of researchers. Here management roles clearly prevail and work focuses on the most strategic R&D level. It is obvious that these three paths follow a certain pattern of progression. Success is usually conceived as achieving a research management position, whilst companies have to make efforts in order to offer career prospects to those researchers who wish to remain on the 'expert path'. Several studies point out that this is not the case in many companies in which scientific and technical roles do not allow for progression up the career ladder. In general terms, successful industrial researchers do not stay in R&D, except for a few who become experts; they turn to management careers instead because of the lack of promotion opportunities in R&D (Godfroy-Genin, 2009; Herman, 2009).

Research reflects a certain ambivalence towards the dual professional system from the perspective of gender equality. Some authors highlight that recruitment in R&D activities is one of the most effective strategies for women to reach high management positions in companies (Marry, 2004). Others point out that it entails not only giving up research, but also a 'technical identity' that women have usually adopted with substantial effort in a male-dominated field (Faulkner, 2007b). Furthermore, the opportunity to change from a technical career to a management role usually appears at around 30-35 years, coinciding with the period of family formation: the management career, like the academic career, is implicitly based on a traditional masculine model. This is a general trend in management, but it is particularly important in R&D companies with a dual professional career path system: not taking the 'right decision' at the 'right time' may entail losing any possibility of career advancement (Herman, 2009).

Finally, other studies highlight that this ambivalence is also present in women's own narratives. When talking about their careers, they stress passion, interesting topics and personal development; yet they refer to a career ladder, hierarchy and power: 'The discourse about the women researchers' career definitions reflects the existing paths of management and expert careers in industrial research but also creates a picture of a holistic career, in which pleasure with the work content, personal growth and a satisfying private life can go along together. The various personal career definitions emphasizing something

beyond management and expertise also showed that the two-ladder model in industrial research is probably not sufficient to motivate and hold people in the company in the long term' (Thaler, 2008, quoted in Godfrey-Genin, 2009, p. 88).

Productivity and mobility criteria

Productivity in industrial research is not based on publications, as in academia, but rather on the number of patents or other achievements in industry, which are usually confidential and

Box 31. Gender differences in career entry and career advancement of 'excellent' graduates

Even 'excellent' graduates experience gender discrimination when it comes to developing a professional career. This study analyses gender differences among 'excellent' graduates in career entry and career advancement. For this purpose, the study selected the graduates in the 1997-1998 academic year who achieved the 15 highest academic reports in a number of universities and fields of study (taking the final average of their academic results). In order to analyse professional development, the study relies on the active collaboration of a sample of 45 large and mid-size enterprises operating in Barcelona, Granada and Madrid. The total sample of excellent graduates is made up of 630 graduates. The first finding of the study is that women are over-represented among excellent graduates (60.5% women and 39.5% men), although there are relevant variations by field of study: the presence of women is greater in humanities and social and health sciences; slightly higher in experimental sciences and, on the contrary, very limited in technical degree courses. The study shows the extent of gender discrimination in career entry by analysing selection procedures: more than 80% of enterprises place high value on time and mobility requirements (changing working schedules, frequent travel, geographical mobility), assuming the stereotype that men will fulfil these requirements more readily than women. On the other hand, the study shows that women with temporary contracts double the number of men in the same situation; they enjoy less autonomy in their job, receive less recognition from their employers when they make suggestions that contribute to the organisation and face more difficulties in achieving the highest positions. These findings confirm the initial hypothesis of the study, demonstrating that women's careers begin later, progress more slowly and are shorter than men's. The study shows the persistence of the glass-ceiling effect which prevents women from being promoted on an equal footing.

De Vicente, A., Arredondo, J.M. & González, M.J. 2004, *La excelencia académica de las universitarias españolas, demandas del mercado e inserción laboral. Incidencia de las políticas de igualdad de ámbito nacional y de las comunidades autónomas*, Ministerio de Educación y Ciencia, Madrid.

are therefore hard to formalise. Sex-disaggregated data about patentees are scarce, but in general reflect the fact that only a few women appear as senior researchers in patent applications; their presence is certainly lower than their presence among industrial researchers (Rübsamen-Waigmann et al., 2003). In the case of women in construction-related research, the *Women-Core* study found that patenting does show significant differences between male and female researchers. Only 10% of female researchers are patentees, and this percentage drops to 4% when the patent is licensed. For men, these figures are 16% and 11% (Vallès et al., 2009).

Mobility is another relevant criterion for promotion in industry. Certainly mobility is a prerequisite for academic careers, usually in the early stages, and especially in some disciplines. In industry the mobility requirements are more pervasive: particularly in the large ICT and energy multinationals, availability to travel is an important element for professional progression and promotion, as it tests commitment to the company (Herman, 2009). A successful career in a multinational without a considerably long period abroad is inconceivable (EC, 2006b). In other cases, frequent mobility between companies is the most straightforward way to career progression, because companies, with the exception of large corporations, offer little career prospects. It is what Valenduc et al. (2004, p. 30) call 'nomadic careers' in the case of ICT: 'Several studies show that ICT companies want their staff to be highly devoted to work, to accept all forms of flexibility and to offer total availability to the employer. At the same time, these same companies weaken the guarantees of job security: reorganisations, downsizing, closures and businesses process re-engineering have demonstrated to the workers that competence, performance and availability are not sufficient to ensure job security. As a consequence, the workers must now manage by themselves

their employability and career. The expressions 'nomadic career' or 'boundaryless career' illustrate these new forms of professional trajectory, in which work relation is based on the development of employability as a counterpart of performance and flexibility, whereas the traditional work relation exchanges job security against loyalty'. Some authors argue that this pattern may be positive for women, because it adapts to their already discontinuous professional career path due to family commitments (Bender et al., 2001). Valgaeren (2005) contends that the nomadic career certainly corresponds more to the reality of women's professional paths, whilst success in the classic linear career is more typical for men. Other authors, however, stress that women are, nevertheless, disadvantaged in the development of professional networks and the investment in training by time and mobility constraints (Bailly et al., 2000).

Lack of inclusiveness

Several studies have analysed overt and covert forms of gender discrimination in SET companies. They appear to be closely connected to the long hours culture and the lack of flexibility in balancing a professional and private life, shaping an organisational culture which lacks the atmosphere of inclusiveness. Research in this field has developed most in English-speaking countries, particularly regarding engineering, ICT and large corporations.

Evetts (1996) analysed the careers of female scientists and engineers in large industrial organisations, addressing the difficulties experienced in the workplace, especially their experience and awareness of gender and their attempts to manage relationships with co-workers, managers and clients. The main conclusion was that difficulties are not associated with the culture of engineering itself

Box 32. Between nepotism and reflexive standards. Personnel policies and career chances in industrial research

This study describes and analyses career chances of male and female industrial researchers in chemistry. For the study, 9 male and 9 female researchers were interviewed, and 8 expert interviews were conducted with representatives from research management, the gender equality group and the work council. Industrial research differs from academic research in that there is a much greater variety of career promotion prospects and possibilities for an earlier acceptance of management responsibilities. Industrial research organisations open up more diverse job promotion opportunities for academics than do governmental or academic organisations, but career progress means paying the price of less research work. The analysis of career paths has shown that the glass ceiling hinders women from attaining high-ranking positions or positions in management and that there is a clear tendency for women to be left behind in the salary hierarchy even if they fulfil the formal criteria to reach high positions. One of the reasons for this is that men and women's career orientation is judged differently: a career-orientated woman is seen as 'undiplomatic', whereas a male colleague focusing on his career will be called 'targeted'. Furthermore, the organisational culture of the company studied is extremely masculine in its connotations, and this systematically reduces opportunities for women. The myth of 'sameness' will not open up new possibilities for women, as the restricting factors built by the masculine culture are too dominant, as are stereotypical gender roles and gender-embedded behaviour expectations. In addition, the image of the 'ideal manager' further reduces possibilities for women. Standardised procedures of personnel development should allow for more transparent assessment, but they are not free of subjective perceptions and the possibility of interpretations by superiors. Therefore a gender neutral judgement is not guaranteed.

Matthies, H. 2005, *Zwischen Nepotismus und reflexiven Standards. Personalpolitiken und Karrierechancen in der Industrieforschung*, Wissenschaftszentrum Berlin für Sozialforschung. Downloaded on 09/10/2008, available at:

<http://www.pdfdownload.org/pdf2html/pdf2html.php?url=http%3A%2F%2Fskylla.wzb.eu%2Fpdf%2F2005%2Fp05-102.pdf&images=yes>

or women's feelings about and experience of using technology and generating technical solutions. The problems of career development lie in the implicit gendered expectations of employees and the processes and structures for promotion and the implementation of organisational policies.

Bagilhole, Dainty and Neale have extensively explored the situation in large construction

companies, focusing on organisational structures and their effects on women's professional careers (Bagilhole et al., 1997; Dainty et al., 1999; 2000). According to these studies, a strong competitive entrepreneurial culture prevents women from being professionally promoted through a combination of two mechanisms: inflexible working practices and discriminatory behaviour. These mechanisms are maintained

through small independent work teams coordinated by male operational managers who control the processes of team recruitment and promotion. From this position, they reproduce a working culture that is intolerant of those candidates who do not fit the traditional profile. These patterns are exacerbated by a general lack of promotional opportunities which have led to congested career hierarchies within the middle management levels. This has resulted in animosity towards women, who are seen as threats to the limited promotional opportunities available within the organisations. Animosity is manifested in overt and covert discriminatory behaviour ranging from overt harassment and bullying to covert discrimination in the form of the maintenance of a culture of long working hours and enforced geographical instability. This strand of research takes a pessimistic view of current strategies to reduce segregation based on the idea of the critical mass when male-dominated culture is so deeply embedded. Powell and Dainty (2006) argue that in this kind of work environment, women change their behaviour to fit the culture they work in so that the critical mass of women entering masculine employment areas will not automatically bring change in work cultures, and isolation will persist.

Studies about the ICT sector also show that a male-dominated environment can be hostile and discouraging for women. Gurer and Camp (1998) state that there is 'subtle but constant' discrimination against women in a prevailing male environment such as that of computer scientists: women are likely to face discrimination sometimes unconsciously expressed by male colleagues through their behaviour, jokes or discussions. For Spertus (1991), sexist humour, sexual displays, discussions and difficulties in socialising with male colleagues may cause female ICT professionals to feel uneasy and uncomfortable. Laufer (2000) stresses that in a masculine

environment, women may lack a mentor or colleagues' support, which may make them more likely to leave when a problem arises. Other authors refer to paternalism and more explicit sexist practices (Adam et al., 2004; Pourrat, 2006). However, Valenduc et al. (2004) contend that these trends are not as widespread as is sometimes claimed: their study shows there are cases of both exclusionary and supportive work cultures, without a clear pattern.

Research also points to more or less subtle forms of gender discrimination in promotion procedures. Among the complaints from female engineers employed in large corporations, Ayre (2001) includes pressure from allegations of reverse discrimination and perceptions of different standards for judging men and women. Valenduc et al. (2004) find considerable evidence of the persistent stereotyping of women by managers and executives in the ICT industry, particularly in relation to their skills, availability for work and career commitment. In many cases, decisions in favour of a woman tend to be made hesitantly even if she is better qualified than the men who apply: whoever chooses a woman has to justify his or her decision even more strongly and confront suspicions of tokenism. Matthies (2005) analyses how gender stereotypes, the duality between management and expert paths and male-dominated nepotism combine to hinder women's career advancement in industrial chemical research. A formal level of gender equality is not a guarantee of gender neutrality. However, the 'myth of equality' which is present in many companies, contributes to making existing gender asymmetries a taboo topic. Singh and Vinnicombe (2002) identify gender differences in the reported meanings of commitment from high-tech engineering managers that may have an impact on the assessment and career prospects of women when evaluated by the mostly male engineering managers. Many other studies refer to the disadvantages of

women when it comes to career progression as arising from homosociability practices. Visibility to management remains a key factor for career progression and informal networks favour men in this respect. Women are excluded from participation because the networks are built around male homosociability, or outside-of-work contact

during evening hours which clash with home life (Jensen et al., 2005).

Career breaks

Career breaks in industry have not been widely researched. One relevant exception is the UK

Box 33. Women in engineering research: academic versus industrial research careers

'A systematic review of procedures for promotion and criteria for successful career paths in all countries and sectors reveals that academic and governmental criteria and industry criteria¹ are very different. Excellence in academia is essentially based on publications, yet excellence in industrial research is based on patents or industrial achievements that often have to remain confidential.

Career paths themselves are different, as we have observed in our samples: successful academic researchers stay in academic research most of the time, so the retention of women is a concern. In contrast, successful industrial researchers do not stay in R&D, except for a few who become experts; they turn to management careers instead because of the lack of promotion opportunities in R&D. As a consequence, measures to retain women in R&D could go against women's careers if more career opportunities are not created in industrial research.

A last divide concerns human resource management. Industry appears more concerned with gender and provides (apparently, at least) better and more transparent human resource management than academia and governmental bodies. On the contrary, many researchers in academia complained in interviews that recruitment and evaluation procedures were not transparent and are not clearly explained, that career support is very poor, and that there is no official human resource management, so many women discover the rules of the game too late. Almost no researchers told us about helpful careers advisors or efficient permanent careers support services, but the situation varies from country to country. There are lots of programmes² to support women in Germany or in the UK in academia, and these are more or less efficient. In Sweden, industry is often considered more woman-friendly by young researchers because of the lack of human resource management in academia. Regarding gender awareness, sceptical attitudes and hidden or open discrimination were noticeable in academia in some countries, though less so in industry'.

Godfroy-Genin, A.S. 2009, 'Women's academic careers in technology: a comparative European perspective', *Equal Opportunities International*, vol. 28, no. 1, pp. 80-97.

⁽¹⁾ Those criteria have been rather easy to identify for the academic and governmental spheres (even if transparency varies from one place to another). For the industrial sphere, as each company has its own policy, they have been impossible to explore in detail, but the overall picture is common to normal human resource management in companies.

⁽²⁾ Mostly mentoring and training to apply to fellowships and project proposals. Those programmes are often proposed to women only.

project *Equalitec: advancing women in ITEC (information technology, electronics and communications)*, which launched a series of studies to examine the perspectives of women who want to return to the ITEC sector following a career break (Equalitec and University of Bath, 2005). Although the group of women returnees was found to be very heterogeneous, some common trends were identified. Central to the understanding of career breaks is that they are processes which include 'in-and-out' periods; that is, the career break may be followed by a period of part-time work before a subsequent return to full-time work. It is important to distinguish between relatively short career breaks (not more than 6 months), and longer ones. Short career breaks do not have the same impact on professional careers as long ones, especially in terms of loss of confidence or the need for requalification. In general, research about returnees suggests that the length of their break from employment is a significant factor in their ease and level of re-entry as is their level of confidence in their ability to surmount new changes in the industry and the assurance that the culture to which they are returning is sympathetic towards people with family responsibilities (Hughes, 2002; Panteli & Pen, 2001).

A key factor for understanding the professional consequences of any career break is to consider the whole in-and-out process. Most women who take a career break are between 26 and 35 years of age, and their main reason is giving birth and looking after their young children (Equalitec and University of Bath, 2005; Herman, 2009). As Herman states (2009), this kind of short career break is usually followed by a period of part-time work and less availability to travel, to stay at work late, etc. Lack of sleep, arrangements in some cases to continue breast feeding, the organisation of social support networks, etc. form part of the in-and-out process and can affect career progression.

Long career breaks are found to have more serious consequences, particularly in such a dynamic field as ITEC. A long break creates a knowledge gap and subsequently a deficit in confidence, self-efficacy and opportunities to network (Equalitec and University of Bath, 2005; Panteli & Pen, 2008). The prevailing obstacle in industry is the impossibility of having shorter working days or flexible working schemes. In the case of career breaks of over two years, the need to upgrade qualifications may be an important barrier. Women having career breaks of more than two years usually return when their children are older and do so full-time. However, full-time work and working responsibilities make retraining difficult if this is not provided by the company itself. Long career breaks may also have a serious impact on confidence and perceived opportunities with respect to returning. Women who stay home with their children for more than two years find it extremely difficult to come back.

The vanish box

The low presence of women in industrial research does not necessarily imply that industry is more hostile towards women than academia. The low numbers of female industrial researchers should be explained first from the perspective of horizontal segregation in university studies. It is clear that industrial research relies mostly on professionals in the S&T fields: mathematics, natural sciences, life sciences, computing and engineering. With the exception of life sciences, the degrees in greatest demand in industrial research are the most male-dominated. It is not surprising, therefore, that the proportion of women researchers in industry is lower than in universities and public research institutions, which have researchers from a broader spectrum of disciplines (Meulders et al., 2003; Rubsamen-Waigmann et al., 2003).

Box 34. The vanish box

'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 characterised 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 [...]

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'.

Etzkowitz, H., Ranga, M., Conway, C., Dixon, L., Ylojoki, O., Vehvilainen, M., Vuolanto, P., Fuchs, S., Kleinert, C., Achatz, J., Rossman, S., Banciu, D. & Dumitrache, N. 2009, *Final Activity Report. The Vanish Box: Disappearance of Women in Science; Reappearance in Technology Transfer*, p. 5.

It is well known that the literature shows that, in general terms, the more bureaucratic, formal and transparent personnel practices are, the weaker gender segregation is (Reskin & McBrier, 2000). However, we have revised a large amount of the literature, which shows that this may not be the case in academic institutions. Informal networks and non-transparent cooptation procedures play a major role and leave room for gender bias, whilst the rigidity of the early stages of the academic career track penalises women's career prospects. There is indeed fragmentary research showing that academia may be seen as a more hostile workplace for women than industry, especially in countries such as Denmark in which the academic career track is particularly insecure and competitive. Nexø Jensen (2003) shows that academia in Denmark educates more than 60% of PhD

students, but subsequently employs less than 25%. More female than male PhD students are on a career path leaving academia, and the prevailing view among students is that the private sector offers better working conditions and career prospects.

Some studies stress that human resource management differs substantively in industry and academia. The tradition of academic autonomy has meant that the human resource function of universities is underdeveloped, meaning that protection afforded to underrepresented groups is not as strong as in other organisations (Ledwith, 2000). Finch (2003) considers that inequality is endemic in these institutions since it is replicated, reinforced and sustained by its many different, yet interdependent, occupations and hierarchies. Academics are members of an

unusual profession in that an individual's merit is not evaluated solely by their employer but also by an external audience of academic peers, editors, founders and students/patients. In industry, human resource management can contribute more to fostering an inclusive work culture. The Prometea study (Godfroy-Genin, 2009) finds that this perception is shared by many female researchers in engineering, who think that industry provides better career support and more transparent recruitment and promotion procedures, sometimes with a tight focus on recruiting talent and on diversity management. Nina Smith, Vice-Rector at the University of Aarhus, Denmark, argues similarly: 'My impression is that in the most progressive Danish private firms – not all private firms – there is a much more positive view on diversity management with respect to gender and ethnicity. In academia I also think times are changing – maybe as a response to the development in the private sector' (Smith, 2008, p. 48). She thus contends that academic institutions should apply the kind of professional human resources management that most progressive private firms are already applying: 'There is an open window now for changing things by applying more general instruments that assist in

professionalizing human resource policies and practices relevant for both men and women. These are mentoring and talent nursing policies, transparent and fair recruitment processes, family policy, child care, and workplace culture etc. This is exactly the same type of policies that you can now find in many private firms!' (p. 50).

Indeed, recent empirical evidence points in that direction. Such is the case, for example, of biotechnology firms, in which flat structures and networking appear to offer better scientific career prospects for women than universities or large corporations (Smith-Doerr, 2004). Or the fact that an increasing number of women scientists have been found to leave academia in order to take up careers in other science- and technology-related professions, which provide not only new career paths, but also more favourable working conditions that meet women's needs better than academic science does (Ranga et al., 2008). Etzkowitz et al. (2009) call this phenomenon of women's disappearance and reappearance the 'vanish box', and claim that it is a more accurate representation of gender attrition in the higher echelons of the academic career than the 'leaky pipeline'. We deal with these new developments in the next chapter.

3

GENDER, INSTITUTIONS AND KNOWLEDGE

3.1 Institutional change

In the previous chapters we have reviewed the literature dealing with gendered structural constraints and subtle discrimination in both academic and non-academic settings. The focus was on the mechanisms that account for the persistence of gender inequality in science in spite of the societal trend towards more equal gender relations. This chapter focuses on current changes in research institutions and their ambivalent impact on gender equality in science. We review the literature dealing with the restructuring of universities under new managerial criteria; the erosion of hierarchy and individual competition in certain university departments and R&D firms; the development of technology transfer professions and, finally, the sociopolitical change in Eastern countries and its impact on gender relations and scientific careers.

3.1.1 *Institutional change in academia*

Institutional change in universities –and sometimes in large public research institutes as well– is driven by the so-called initiatives of New Public Management (NMP), which are intended to resolve the alleged inefficiency and excessive bureaucracy of public institutions by introducing a market logic in the non-mercantile public sector. Central to this restructuring is the fostering of competition for financial and personal resources within and between academic institutions. NMP thus challenges the fundamental tenets of the traditional model of academic freedom, i.e. unconditional funding and minimal state intervention in the management of the system (Becher & Kogan, 1992; Parker & Jary, 1995; Prichard & Willmott, 1997). Managerialism is channelled through the development of greater levels of monitoring of both institutions and individuals through a range of regulated evaluation schemes and performance measures

that are meant to foster efficiency by increasing competition and financial accountability. NMP initiatives first developed in the 1980s in UK universities, coupled with substantial cuts in public funding, a growth in student numbers and overall pressures to intensify teaching and research work (Barry et al., 2001). According to some authors, the end result of this process is an academic production line on the model of the ‘McUniversity’ (Parker & Jary, 1995). NMP initiatives were later transferred to a greater or lesser extent to other national contexts, in a general trend towards increasing competition for public funding and emphasis on transparency and accountability in the allocation of funds. The traditional approach of direct steering by public ministries of science and education has thus been changed: detailed control of inputs and processes is replaced by control of outputs and results, with greater external evaluation of research production and teaching.

The gender dimension of this institutional change has been approached very differently across national contexts (Caprile & Vallès, 2010; Castaño et al., 2010). Whilst the literature in Germany, Austria or Switzerland explores the ways in which NPM might serve to foster gender equality in academia, the literature of the UK, where NMP has been in place longer, focuses rather on its gendered impact on the academic profession. Parallel to this strand of studies, other authors focus on institutional change at the departmental level, highlighting the emergence of less hierarchical, more collegial and inclusive departmental cultures that offer women more opportunities for career advancement.

New Public Management

Several studies analyse the experience of NMP restructuring in UK academic institutions from a gender perspective. Thomas and Davies

(2002) contend that the restructuring of higher education appears to be geared towards a highly individualistic and competitive culture that promotes a masculine subjectivity and career path that does not contemplate other career options and domestic commitments. Their qualitative study in three universities shows the extent of female faculty's concerns over the intensification of work and the increased working hours, coupled with increasing student numbers, shrinking resources, the widening range of academic tasks, the increase in administrative tasks and greater accountability for performance. Academic women also emphasised the development of a strong performance culture, with primacy given to research-based activities in terms of institutional and managerial targets. The devaluation of teaching was seen as an additional source of strain. Overall, 'academic life was perceived to be much more competitive, ruthless and single-minded, with the pressure to publish and generate income resulting in a self-protecting, self-serving, less collegiate and more 'divide and rule' atmosphere' (Thomas & Davies, 2002, p. 383).

Restructuring in the public sector has been shown to disadvantage women particularly at certain stages of their life and career. For example, women with caring responsibilities who do not have flexibility in their lives outside work to make a commitment to 'long hours', the spill-over of work at home via remote technology or outside-of-work study to meet new qualification expectations (Bennett & Tang, 2008). Looking at science occupations specifically, Leonard (1998) studied the type of posts created through restructuring the management hierarchy and concluded that a focus on finance, commercialisation and facilities management have strong masculine associations which have had negative consequences for women's promotional prospects. Knights and Richards (2003)

further highlight that academic restructuring is coupled with a rapid increase in fixed-term contracts that disproportionately affects women. Many temporary staff are on research contracts, which are normally of a short fixed duration owing to the nature of research funding. However, they also point to a growing trend of using fixed-term contracts – sometimes rolling contracts – for full-time teaching positions. Others have looked at the knock-on effect in workplace culture and concluded that managerialism can give rise to a 'bully-boy' culture in which men fare better than women (Leathwood, 2000). Barry et al. (2006) provide one of the few comparative studies on the gendered impact of NMP in England and Sweden. Drawing upon more than 60 semi-structured interviews, they stress how the new managerial requirements elicit different identity-management responses. Despite cultural differences and the time lag in the introduction of reforms between Sweden and England, it emerges that women academics in both countries face more difficult compromises than their male counterparts to sustain working in higher education. It would appear that especially women in middle range positions wanting to advance their careers have been left with fewer choices of positive identities under the new managerialist approaches.

Central to NMP restructuring is the development of an external assessment system to compare the quantity and quality of academic work and financially reward departments and universities, which in the case of the UK is institutionalised through the Research Assessment Exercise (RAE). Several authors highlight the double-edged nature of this trend. Thomas and Davies (2002) state that the promotion of measurable, gender-blind performance criteria can be viewed as a challenge to the traditional practices of patronage and nepotism, although this trend is parallel to the intensification of work and

individual competition and may thus exacerbate gender differences in career outcomes. In a similar vein, Knights and Richards (2003, p. 390) argue that 'in seeking to reverse generations of sexual inequality, it is probably necessary simultaneously to support and criticize meritocratic systems of equal opportunity or remain ambivalent in the same way as Foucault (1984) suggests using enlightenment reason against itself. In this sense, we have to defend universal meritocratic values insofar as they help women and minorities to challenge discrimination on any other grounds. But it is important to recognize the tendency for meritocracy and masculine conceptions of reason to privilege what can be measured, thereby reproducing prevailing gender distributions of advantage within academia. In relation to the RAE in UK academia, this would involve recognizing that we cannot simply universalize the concept of merit but have to situate it within the context of its use'.

Measurable performance criteria are mostly based on bibliometric measures. Addis (2010) summarises as follows the literature dealing with gender and bibliometric criteria:

- a) bibliometrics is gender-blind, i.e., it does not differentiate among scientists of different sex, and this may be turned to the advantage of women because it gives a clear standard according to which men and women scholars can be compared;
- b) bibliometrics is gender-biased, because it has some shortcomings which appear more evident in relation to its application to scholars of the two sexes. These shortcomings are the bias in favour of the past and the bias in favour of position in the network of relations, i.e. bibliometrics reflects the bias in the system;
- c) one should distinguish between bibliometrics *per se* and the use of bibliometrics. The use of bibliometrics is often not gender-neutral

because bibliometrics is attached to elitist strategies in the allocation of scientific resources which may work against women's integration in science. There is no reason, however, why it should always be so. A spurious connection is created between 'excellence/elitist allocation/bibliometrics', on the one hand, and 'non-excellence/egalitarian allocation/no-bibliometrics', on the other. This association is false and simplistic. Scientific production is not one-dimensional, from bad science to good science. It is multi-dimensional: there are original thinkers and innovators. Egalitarian allocation produces a plurality of approaches, many of them original, which is the best guarantee of scientific advancement. It may well be that an egalitarian allocation produces as much or more 'excellence' than the elitist strategy. And bibliometrics itself can be used for any policy, not necessarily an elitist one.

In contrast to the UK literature, the German-language literature discusses, mainly theoretically, the potential benefits of NMP restructuring for gender equity in academia (Castaño et al., 2010). This divergence in scope and focus may be at least partially related to the timing of restructuring alongside the major structural differences between the 'Humboldtian' German university model and the Anglo-Saxon one. The German-language literature acknowledges that gender equality in science cannot be achieved by legislation and regulation alone (e.g. Aichhorn, 2000 in Austria or Degen, 2001 in Germany) but at the same time highlights that NMP restructuring might serve to make inroads into the male-dominated and reform-resistant academic institutions; specifically, it is claimed that the NMP may bring greater transparency and accountability and steer the establishment of more systematic links between university reform and gender equality policies. From this perspective, special attention has been paid to the establishment

of Equal Opportunity Officers within the universities. Several studies stress the difficulty involved in evaluating the real influence of such officers in the light of the informal procedures and silent agreements that are often more important in appointment procedures than the formal regulations (i.e. Müller, 2000; Steffens et al., 2004). Interestingly, the empirical study of Wroblenski et al. (2007) concludes that Equal Opportunity Officers contribute substantially to the professionalisation of appointment procedures in terms of transparency, accountability and comprehensibility, which is considered a precondition for identifying and preventing discrimination. However, they are largely limited to operating on an informal basis, at best encouraging women to apply: in the case of conflicting situations their intervention is usually ineffective and strongly stigmatising for the women concerned.

The German literature also provides a paradigmatic example of 'good practice' in the long-term development of a comprehensive strategy of university restructuring tied to equality policies, the Free University (FU) Berlin. The FU was among the first German universities not only to implement promotion measures for women, but also to put into practice an internal performance-oriented allocation of funds. Färber (2000a, 2000b, 2007) analyses specifically the impact of this funding system in relation to teaching, research, recruitment promotion and women's promotion. She contends the 'practical success' of the women's policy concept, which she argues is related to the fact that the legal base for the performance-related allocation of funds, implies a strengthening of the women representatives' position in top level decision commissions. The reports issued by the Gender Equality Officer of the FU (Koreuber, 2008) give more recent insights into the positive impact of making faculties responsible for co-financing new positions. Thus, by combining a faculty-specific budget with financial

resources available for hiring women, faculties were able to create more positions, which led to a considerable increase in the number of women academic staff.

Departmental cultures

Some UK studies deal with the emergence of more supportive and collegial forms of leadership at the departmental level, finding that some middle-managers take a transformative stance with regard to the 'hard' managerialism practised by senior managers at the strategic institutional level. Goode and Bagilhole (1998) single out women as 'transformers', whilst Barry et al. (2001) find both men and women managing supportively, alongside widespread resistance and disaffection towards hard managerialism. Hasse and Trentemøller (2008) also conclude that there is a considerable degree of variation between departments and stress the emergence of more inclusive, collegial and family-friendly departments even in countries such as Denmark, where the academic culture is particularly individualistic and competitive. Overall, this strand of the literature highlights the importance of the departmental level for fostering women's presence and career advancement in academia.

One of the most comprehensive studies is that of Etzkowitz et al. (2000) in the US. Having analysed a series of departments in different scientific fields, they conclude that change is taking place in the departments, although it is dependent on departmental leadership. Departmental attitudes toward women students and faculty form a continuum, in which two ideal types can be identified at the extremes. The instrumental departments, with a small number of women in isolated positions, are characterised by a highly hierarchical power structure headed by the 'eminent male older scientists'. In relational departments, with a relatively high proportion of women, there is

a less hierarchical and more collegial atmosphere that fosters professional collaboration between the members of the department. Finally, the study identifies four types of change strategies that can help make departmental cultures more relational, of which the last appears to be the most successful:

- *Bottom-up programmes:* Informal interventions by the women of the department that normally start as a voluntary social movement. This kind of initiative is highly flexible, low-cost and enables ad-hoc monitoring of conflicts and the needs of the department without administrator intervention.
- *Top-down programmes:* Administrator initiatives which often have a structure of incentives that promote change in the faculties by providing financing. For these to be successful, they require the involvement of faculty and students in their design, implementation, monitoring and assessment.
- *Idiosyncratic programmes:* Programmes in which a person tries to introduce a specific change or fill a void in the system in relation to the women's situation in the department. They may be very successful when an individual's efforts are recognised by other individuals with more power in the institution who see the idiosyncratic change as a model for other programmes.
- *Strategy for departmental reform:* Initiatives led by the departmental manager or those who have departmental power. This type of strategy may show the potential of the new organisation of scientific work if it can involve a critical mass of male and female faculty members who are like-minded in relation to issues concerning career and family balance, the tenure clock and other specific obstacles that many women and some men come across along their scientific career path.

3.1.2 New developments outside academia

The literature shows that engineering has proved remarkably resistant to gender change in spite of several decades of public and private efforts to promote women's presence and decision-making. This is also the case of ICT, a relatively young professional field, which was initially expected to be less bound by gender prescriptions. In spite of this, there is fragmentary evidence from gender experts and women scientists showing that academia is more hostile to women than certain technical fields, such as biotech or technology transfer. Recent developments in these fields suggest new lines of reflection and research, as shown in the paragraphs below.

Biotech industry

Smith-Doerr's study (2004) of biotech firms in the US suggests that flat network organisations offer better prospects for women's scientific careers than large hierarchical organisations. The development of the biotechnology industry since the 1980s exemplifies the emergence of a new organisational model of scientific knowledge production that contrasts with the large pharmaceutical corporations and established universities. Typically, biotech firms are founded by academic scientists with venture capital backing. They tend to be small, research-intensive organisations, primarily concentrating on genetic engineering and molecular biology for human therapeutic and diagnostic applications. Their ability to remain on the cutting edge of scientific development and innovation is based on the successful management of interorganisational networks: collaboration with universities and research institutes for basic science, with pharmaceutical corporations and hospitals for clinical testing, and with venture capital for funding and management advice.

Smith-Doerr compares the gender patterns of the entry and promotion of life scientists in two distinct settings: 1) academia and large pharmaceutical corporations traditionally organised with hierarchical career ladders and 2) biotechnology firms governed by networks, with project-based teams, flatter organisational structures and multiple ties with external collaborators. Her study is based on the statistical analysis of the careers of about 2,000 life scientists, combined with interviews with male and female researchers in both settings. The study does not find any distinct pattern of masculinisation/feminisation: In the 1980s and 1990s, biotech firms offered job positions to about 8% of life scientists and male and female scientists were found to be equally attracted. However, she finds that gender differences are relevant in terms of career prospects: women in biotech firms are about eight times more likely to head a research lab than in more hierarchical settings, whilst no significant difference is found for men.

The study contends that contrary to expectations, this kind of network with flexible structures offers better protection from discrimination than bureaucratic organisations. While bureaucratic rules create accountability in employers and enforce direct disincentives for discrimination, the network form of organisation produces the same functions through other mechanisms with greater efficacy. Smith-Doerr argues that there are three main reasons why flexibility places constraints on discriminatory behaviour: (1) increased transparency in organisations, (2) a greater choice in forming collegial relationships, and (3) collective rather than individualised rewards. Transparency means that those who hire and promote are accountable to many others outside their office –including, in biotech, venture capitalists and external scientific advisers. The project-based nature of the work allows scientists a greater choice in selecting research

collaborators whilst collective rewards favour diversity and collaboration, in contrast to personal networking for individual rewards in bureaucratic organisations. Flexibility is also especially appealing to women because it also means greater opportunities to do challenging research with fewer institutional constraints, especially the tenure clock. A central tenet is that in biotech firms the power difference between management and knowledge-producing employees is not as great as in more hierarchical organisations such as traditional pharmaceutical corporations. Thus, as Smith-Doerr (2005, p. 42) states, 'a scope condition of this increased gender equity in network organizations may be that it is limited to knowledge-expanding sectors. Perhaps network firms that mainly produce goods rather than create knowledge would be less likely to include individuals of different ethnicities or gender in the trusted circle'.

The study focuses on the new organisational forms of knowledge production and their consequences for gender equality in science. It is a common finding that women are usually well represented when a new field emerges at the periphery of science, but are then pushed out when the status of the field rises. Patterns of masculinisation and feminisation in science related to centrality and status are well documented. However, as Etzkowitz (2007) stresses, this is not the case of the biotech industry. Women's presence in high positions persists now that biotechnology has been consolidated as one of the most dynamic scientific fields. More recent studies further explore this pattern, showing that women scientists in biotechnology are more likely to become patent-holding inventors than in more hierarchically arranged organisational settings in industry or academia (Whittington & Smith-Doerr, 2008; Whittington, 2009). If other studies confirm these findings, the transformation of scientific work from hierarchical organisational to flat network

structures could be seen as one of the driving forces towards gender equality in science.

Hybrid professions in science/ business interfaces

In recent years, research on gender, science and technology has also been concerned with the emergence of new science-related professions. These new professions develop at the intersection between science and the economy and are based on a mixture of scientific and business roles: technology transfer, incubation and scientific entrepreneurship (TIE). As the products of science have become more relevant to achieving political and economic objectives in recent decades, the importance of linkage mechanisms between university and industry has increased. In order to bridge the gap between the achievement of R&D results with commercial potential and the creation of new economic activity, formal methods of university-industry collaboration, such as venture capital firms, incubator facilities and science parks, have been promoted. Their role is to facilitate the process of transferring research results into economic goods. Innovation literature has paid considerable attention to these interface areas, but the people who engage in these emerging professions have barely been studied, and much less from a gender perspective. However, such an approach is of particular interest in examining whether women who have left academia successfully reappear from the 'leaky pipeline' in science-related occupations that have opened up as a result of the increasing economic and social importance of science. This was the aim of the WIST project (Etzkowitz et al., 2009), a comparative study of TIE professions in the UK, Finland, Germany and Romania, which draws on previous research in the US (Etzkowitz, et. al., 2000).

In terms of gender equality, the WIST study finds common tendencies, both positive and

negative. TIE professions require hybrid competence: one has to understand research logic, to have experience and understanding of the business world, to be acquainted with research and development funding mechanisms and to have basic knowledge about policy making. However, TIE is in an incipient stage of professional institutionalisation, with a flat career ladder and an under-developed system of professional recognition and promotion. It is a demanding professional field in which long working days prevail, although time organisation is also highly flexible and offers better opportunities for balancing professional and family life than other professions, especially academic science. It is a field devoid of ageism –on the contrary, age and experience are generally appreciated and benefit both sexes, including people who take career breaks and those who shift careers. In general, a good working atmosphere and high satisfaction predominate, although low salaries are relatively widespread. These are common trends in all the countries analysed, although differences are found in the extent of women's presence in high positions and the degree of influence of informal networks: '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 to 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' (Etzkowitz et al., 2009, p. 16).

The case of Germany is useful for illustrating the mixture of positive and negative trends in which technology transfer appears to be a double-edged sword for gender equality. In the framework of the WIST project, Achatz et al. (2010) analysed the careers of people working in technology transfer at the university-industry interface. They show that while on the surface technology transfer is almost perfectly gender balanced, marked gender differences exist between and within the transfer organisations. The study finds a 'motley crew' with a diversity of disciplinary backgrounds, professional experiences and career expectations, as well as significant differences between men and women. Three types of entry to the field are identified: 1) the 'accidental' movers, a balanced category of men and women coming to technology transfer primarily by chance, from an academic, but mostly non-S&T background; 2) 'strategic' movers, a predominantly male group entering the field mostly after pursuing a career in S&T, and 3) 'forced' movers, an exclusively female group entering the field after a career break, most often after a 'forced decision' resulting from the impossibility of returning to a scientific career after a maternity or child-care leave. Such women tended to view technology transfer as a 'second best' alternative to a scientific research career, while men tended to view it as a useful jumping off point for a career in science-related business.

Overall, the proportion of women among staff in technology transfer organisations in Germany is higher than that of women among academics or faculty. In a within-field comparison, however, the proportion of women is particularly low in the transfer activities of the prestigious German umbrella organisations. Technology transfer in umbrella organisations is more professionalised than in German universities, and is sometimes set up to circumvent the boundaries characteristic of public service in Germany, for example regarding legal status (limited liability companies) and salary structure – characteristics that might draw a larger pool of people to technology transfer in general, and more men in particular. The authors thus conclude that women's opportunities and gains are fragile because of the still transitory nature of the field. Technology transfer in Germany may be seen as a double-edged sword: 'given that almost half of the women we interviewed are working part-time, the intersection of 'career' and 'flexibility' in technology transfer together with a considerable workload then becomes a double-edged sword. Technology transfer in Germany offers responsible and flexible work and the opportunity to balance career and family to all. However, female scientists disproportionately make use of this opportunity, thus amplifying the potential gender bias in German technology transfer by running the danger of being expelled to the less rewarding jobs and organizations in the field' (Achatz et al., 2010, p. 83).

3.1.3 Sociopolitical and institutional change in Eastern countries

In this last section we deal with the literature addressing sociopolitical and institutional change in the former socialist Eastern European countries. In spite of specific national trends, the lives of women scientists in the Eastern

countries have a series of common characteristics that are related to a general context of socialist history and post-socialist transformations –full of contradictions and paradoxes– in which both gender relations and scientific institutions have experienced important changes. This overview is based on the *Enwise* report (Blagojevic et al., 2003) and the first part of the country-group report of the Eastern countries (Sretenova, 2010).

The gender contract and the scientific career during socialism

During socialism, the prevailing gender contract was characterised by its ambivalence and contradictions and could be defined as ‘modernisation without liberation’ (Blagojevic et al., 2003). The Soviet model of equality guaranteed women’s access to secondary and higher education and, at the same time, built an intense network of nurseries and services to attend to children and the elderly in order to enable women to work full-time. In the late 1970s, women achieved parity with men in secondary education in all countries and also in higher education in many countries. Women’s increasing access to higher education continued throughout the 1980s. The structure of female occupation gradually changed and more and more women took on qualified posts, including academic ones. However, the process of female empowerment was parallel to a process of disempowerment, with the reinforcement of conservative gender roles which emphasised women’s safeguarding of traditional values and family life. Horizontal and vertical segregation in the labour market was intensified, with women adopting the role of second breadwinners.

In the 1980s, as a result of the social and economic value bestowed on engineering and technical careers as well as the quota measures established in some countries, the proportion of female graduates in these fields was

considerably higher than in the Western countries, although vertical segregation was equally persistent. However, the mechanisms explaining vertical segregation during the times of socialism may not be the same as those prevailing in Western countries or at the present time. The building of a scientific career during the socialist period had its own specific characteristics (Blagojevic et al., 2003; Sretenova, 2010). There were no female role models, because the pioneers who had gone into the universities before the Second World War were considered the natural enemies of the socialist revolution. The new generations of scientists emerged under conditions in which building a career meant a moral commitment to the regime, including the intellectual censorship of feminism and the impossibility of creating networks or women’s associations. In this context, concepts such as vertical segregation or the glass ceiling were practically unknown. The difficulty in publicly identifying social problems meant that they were rarely analysed, theorised or interpreted. As a result, there was a lack of empirical studies on scientists and scientific institutions, and particularly, on the mechanisms leading to vertical segregation, beyond evidence of the social and cultural persistence of traditional gender roles.

Post-socialist transformations

For all Eastern countries, the 1990s was a decade of transition from a centralised planned economy to a market-oriented economy and from an authoritarian political regime to a liberal democracy. This meant a series of social and cultural transformations that also have a gender dimension. Blagojevic et al. (2003) contend that complex processes of continuity and discontinuity led to the exacerbation of conservative gender roles. Political and economic transformations led to the weakening or virtual disappearance of the whole system of social policies and care services for

Box 35. The situation of women at Universities in East Germany after the turnaround

In contrast to the school system, university staff are overwhelmingly male. There are considerable differences between different countries which cannot be explained by the degree of 'modernity' of a society, as a comparison between Northern and Southern European countries shows. An important factor influencing the opportunities and obstacles regarding women's careers in higher education lies in personnel policies. In this contribution, it is argued that the generally better position of women scientists in the former GDR in comparison to united Germany is not only the result of a different attitude towards female employment (and its corresponding childcare) and a programmatic commitment to women's emancipation (at the top of the hierarchy, among professors, the proportion of women was as low as in West Germany – 5%), but primarily of differences in the personnel policies and structural conditions of the academic career (probation and advancement within a system of basically permanent positions, no forced mobility, no ban on appointments in the 'home' university). In the second section of this text, the mechanisms for the restructuring of former East German universities after the turnaround and its impact on women scientists is analysed: political renewal and dismissal of 'burdened' people, content and scientific renewal, evaluation criteria following West German subject profiles and quality standards, new advertising of all professorship positions, quantitative job cuts, especially in the middle level positions (particularly pronounced in East Berlin), acceptance of West German staff structures and the conversion of the majority of permanent positions into temporary ones. The deterioration in women's situation is less a result of direct discrimination than an effect of the structural changes.

Kriszto, M. 1995, 'Zur Situation von Frauen an ostdeutschen Hochschulen nach der Wende am Beispiel der Humboldt-Universität zu Berlin' in H. Sahner & S. Schwendtner, eds. 27. *Kongress der Deutschen Gesellschaft für Soziologie. Gesellschaft im Umbruch: Sektionen und Arbeitsgruppen*, Westdeutscher Verlag, Opladen, pp. 146-151.

children and the elderly. Whilst this significantly overburdened women and reinforced traditional gender roles, the perceived relationship between women's issues and the official socialist policy meant that antifeminism and anti-communism went hand-in-hand during this decade of transformations.

As regards science, the percentage of the GDP dedicated to R&D was drastically reduced in all countries, except for the Czech Republic and Slovenia. In the universities and public research institutions, a series of structural reforms were implemented, one of the most visible aspects of which was the drastic reduction in R&D staff,

which in some countries was as high as 50% and affected men and women equally. In this context, two 'hot questions' appear to be particularly relevant, not only in general terms, but also from a gender perspective: first, the issue of unemployment among highly educated individuals; second, the issue of migration, including the migration of scientists and academics from the Eastern countries (Sretenova, 2010).

In general, gender research in this field is limited and very little is known about the impact of the social transformations and structural reforms of the academic institutions in the

careers and lives of scientists in the Eastern countries, albeit some interesting reflections and studies stand out. Particularly interesting are some studies carried out in the former German Democratic Republic (GDR) in the 1990s. They underline the deterioration of the situation of women scientists and their career prospects, due to both structural and cultural changes: the restructuring of universities was parallel to the exacerbation of covert discriminatory practices. In a few years, from 1989 to 1992, there was a process of radical structural transformation in the university system in the GDR. This process entailed a drastic fall in university staff, an increase in the use of fixed-term contracts and the overall redesigning of the career track for young scientists. For women, university restructuring entailed a process of displacement from teaching and research (Burkhardt, 1993). Although one of the promises of the German reunification process was that the percentage of women scientists would increase, in fact reform meant the adoption of the West German model, which was more exclusionary towards women (Felber & Baume, 1997). Kriszto (1995) contends that the deterioration of women's situation was less a result of direct discrimination than an effect of structural changes, namely the acceptance of West German staff structures and the conversion of permanent positions to temporary ones. Hildebrandt et al. (1992) further highlight that discriminatory trends were also shown in the enforcement of traditional role models to the benefit of men, the increasing lack of interest in women's research and the dismantling of the institutional representation of women's interests, such as women's promotion plans and women's commissions.

European integration

During the 2000s, structural reforms in R&D systems in Eastern countries have shown a general move towards the adoption of NMP

approaches. A central aim is to foster competition both at the level of individual scientists and institutions, and especially to attract research funding outside the allocated state budget subsidies. A second objective is to support the collaboration and links between public institutions and private companies (Sretenova, 2010).

After the drastic fall of R&D staff during the 1990s, the number of researchers and university staff began to increase again, although the problem of 'brain waste' is still significant and affects women in particular. Blagojevic et al. (2003) made a distinction between 'brain drain' (which involves the circulation of human capital) and 'brain waste' (which involves loss of human capital). Research lends support to the hypothesis that in most Eastern countries internal and external brain waste predominates over the brain drain. This mainly affects highly qualified women, given that women with economic difficulties tend to be more willing than men to accept jobs that are beneath their qualifications and, in general, work for lower pay.

Increasing competition in science is also leading to significant changes in the vital strategies of young scientists, especially women. Career and family tensions appear to be more acute nowadays than in the past. As already stated, several studies show a shift in the vital strategies of young women scientists, who tend to give higher priority to their professional career, delaying the age at which they marry and have their first child (e.g. Blagojevic et al., 2003; Mařicová, 2004; Tornyi, 2007).

In parallel, other studies stress the persistence of vertical segregation, in spite of a positive trend towards the improvement of gender equality in universities in most Eastern countries. According to Sretenova (2010) this is not a result of the adoption of new organisational approaches and/or the

Box 36. Family and work in the life of Czech women scientists across generations

Comparative studies about the situation of women in science during socialism and democracy are still very limited. A relevant study is that of Mařicová (2004). This is a qualitative interview-based research depicting the differences between the experiences of young women scientists who built their career in the 1990s and older women scientists who built their career under the state-socialist regime. The data were collected as an outcome of the project Women in Academy of Sciences –Position of women in the structures of the Academy of Science between the years 1953 to 2000, funded by the Czech Academy of Sciences. The author stresses that vertical discrimination barely varied in these fifty years, although structural conditions of the career track significantly changed after the end of the socialist regime. The study discusses the barriers young female scientists face when entering the academic field and also the problems they encounter when they have a family and children. From the life trajectories of the older scientists, it is obvious that they did not strictly set out to build a career, as can be seen in the stories of the young scientists. Many of them had children first and then they returned to the academic field. Because competition was weaker and chances fewer, especially for scientists who were not members of the communist party, there was no rush for older scientists.

Mařicová, H. 2004, 'Práce a rodina v životě českých vědkyň: generační a genderové srovnání', *Kontext*, vol. 3, no. 1-2, pp. 43-62.

implementation of gender equality policies at the universities. Rather, this positive shift in the figures of academic women occupying the top positions might be interpreted as a result of different processes; academic science in particular has undergone a certain loss of prestige while the private sector is rapidly growing in most Eastern countries. Some male scientists are leaving universities looking for better career and life opportunities either in industrial research, the private sector or abroad. It is therefore contended that current trends in women's presence in science should be analysed taking into account R&D financial issues, particularly R&D expenditure per capita researcher, researchers' remuneration and the gender pay gap. Women's presence appears to be greater in the countries and sectors with poorer R&D financial conditions.

3.2 Gender analysis in research content

In this chapter we present the main results of the meta-analysis of the literature dealing with gender analysis in research contents. To better understand the complex processes involved in the increasing participation of women and minorities in science and technology, Schiebinger (2008b) identifies three interrelated policy approaches to gender equality. The first of these approaches focuses on programmes targeting women themselves in an effort to increase their participation in science and technology. The second approach seeks to increase women's participation by reforming research institutions. The third focuses on overcoming gender bias by mainstreaming gender analysis into basic

and applied research. This chapter focuses on the third approach.

The topic report on gender in research contents presents three articles that review gendered innovations in knowledge production over the past three decades with a focus on current approaches. Here we focus mostly on the general analytical framework presented in the introductory article (Schiebinger et al., 2010). Further details about gendered innovation in biomedical and health research can be found in the article by Klinge and Newman (2010), whilst Schiebinger and Arlow (2010) address gender innovation in engineering and technology. These two latter articles review the literature in their respective areas from

1980-2010 and provide concrete examples of how sex and gender analysis can enhance excellence in science and technology. They are summarised in the last sections of this chapter.

Research has documented that methods, techniques and epistemologies of Western science are not value neutral with respect to gender and other social inequalities. The global leader in terms of policy seeking to encourage researchers to mainstream gender analysis into science and technology is the European Union's DG Research. In 1999 the European Commission adopted an action plan to promote research 'by', 'for', and 'about' women (EC, 1999). This approach focused research on

Box 37. Granting agencies and current policy approaches for mainstreaming gender analysis in basic and applied research

The global leader in policies to promote mainstreaming sex and gender analysis into basic and applied research is the European Union's DG Research. Where do other granting agencies stand on this issue? The DG Research is one of the few S&T research organizations that requires grantees to address gender analysis in grant applications for all fields, although several European countries also include this as part of their national science policies. The United States NSF currently has no programs that address whether or to what extent sex and gender analysis should be used in research. Policies requiring researchers to integrate gender analysis into research are more common in health research organizations. Since 1990, the United States National Institutes of Health has required researchers to reconceptualize medical research to include women and minorities in federally-funded research, but this has not been enforced (NSF, 2009). The World Health Organization mainstreams gender analysis into all –research, policies, programmes, projects, and initiatives (WHO, 2002). The Canadian Institutes of Health has committed to –Integrating Sex and Gender into Health Research (CIHR, 2003). In Europe, Sweden's Karolinska Institute and Germany's Charité Universitätsmedizin have both created centers for gender medicine that promote sex and gender analysis in basic and clinical health research (Haafkens & Klinge, 2007).

Schiebinger, L., Klinge, I., Arlow, A. & Newman, S. 2010, 'Introduction' in L. Schiebinger and I. Klinge, eds. *Gendered innovations. Mainstreaming sex and gender analysis into basic and applied research. Meta-analysis of gender and science research – Topic report*. Downloaded on 16/11/2010, available at: http://www.genderandscience.org/doc/TR6_Gendercontent.pdf

women as a group rather than on gender and did not take into account sex and gender issues in research (Klinge & Bosch, 2001). In the 6th Framework Programme (FP6, 2002-2006), the DG Research implemented its cutting-edge policy requiring that grantees applying for the largest grants (the Integrated Projects and Networks of Excellence grants) include a gender dimension in research. As stated in the call for proposals, research design must specify 'whether, and in what sense sex and gender are relevant in the objectives and the methodology of the project'. The EU's 2003 *Vademecum: Gender Mainstreaming in the 6th Framework Programme* (EC, 2003a) offers guidance to programme officers on how to structure the competitive grant process to ensure that the gender dimension is included in basic research. The gender monitoring studies identified two obstacles to addressing gender in research content: 1) the FP6 did not explicitly outline all the actors' roles and responsibilities related to integrating gender analysis into basic and applied research; 2) researchers themselves lacked an understanding of what addressing gender in the research content meant (CSES, 2009). The European Union DG Research scaled back its innovative research requirement in the FP7 (2007-2013) while simultaneously funding programmes to train researchers in how better to integrate gender analysis into research.

3.2.1 Theoretical approaches

Schiebinger et al. (2010) distinguish four theoretical approaches that underlie much of the work in the area of women and gender in science, medicine, and technology: gender-neutral, difference, co-constructionism, and gender analysis. While to a certain extent, these approaches parallel science policy approaches, they are distinct theoretical approaches that underlie scholarly literature addressing gender in research.

Gender-neutral approach

This approach, which might also be called liberal feminism, was dominant in the 1970s, when women first gained access to graduate education in large numbers and could potentially become professors in science, medicine, and engineering. Since Mary Wollstonecraft's vigorous call for equality in her 1792 *Vindication of the Rights of Woman*, liberal feminism has informed major legislation guaranteeing women's rights, equal education, pay, and opportunity (the 1997 Treaty of Amsterdam, for example). Liberal feminists generally see women as the in-principle equals of men –everything else being equivalent– and therefore strive to provide women the skills and opportunities to 'make it' in a man's world (Harding, 1986; Schiebinger, 1999). Feminism at this level has made such inroads in Europe and North America that most people no longer even think of these issues as 'feminist', but as 'just' or simply 'true'.

Basic tenets

- Supports equal access to education and employment for women and girls.
- Considers science and technology unbiased.

Problems

- Considers science and technology sex- and gender-neutral. Tends to ignore sex and gender differences.
- Locates problems in women (their education, socialization, aspirations, and values). To achieve success, women or girls are often required to assume male values, behaviours, and life rhythms.
- Tends to transfer Western-style science models to developing countries.

Policy implications still valid

- Supports equal access to education and employment for women.

Difference approach

The difference approach (late 1980s-1990s) bears resemblance to the standpoint theory that seeks to represent the world from particular socially situated perspectives that lay claim to epistemic privilege or authority –in this case from women’s perspectives. This approach gave rise to much discussion about ‘women’s ways of knowing’ (Goldberger & Tarule, 1986). Carol Gilligan (1982) famously claimed that women speak ‘in a different voice’ when making moral judgments and that they value context and community over abstract principles.

Basic tenets

- Emphasises sex and gender differences between men and women.
- Uses traditional feminine values to reform science and technology. Importantly, this approach identifies bias in science and technology by seeing what is left out from the feminine side of life.
- Opens definitions of science to include non-Western science and local knowledges (also referred to as indigenous or traditional knowledges).

Problems

- Tends to romanticise traditional masculinity and femininity and play into conventional stereotypes of men and women
- Fails to take into account that men and women across classes and cultures hold many different perspectives and values.
- Tends to essentialise gender characteristics and impute positive traits, such as nurturing, to women. By conceptualising women as the key agents of change, this approach can exclude men.

Policy implications still valid

- Understanding gender bias in science and technology.

Co-constructionism

This approach (1990s-present) sees science, technology, and gender as constructed through social processes rather than as natural or given *a priori*. Social constructionism provides rich analyses of how ideas, objects, and identities emerge from cultural contexts and has been particularly strong in technology studies. Co-constructionism goes one step further to look specifically at how science/technology and gender influence and mould each other.

Co-constructionism seeks to avoid both technological determinism (seeing technology as the prime driver of modernity) and gender essentialism (seeing gender characteristics as innate and unchangeable) (Wajcman, 2007; Zorn et al., 2007).

Basic tenets

- Gender and science/technology are co-constructed.
- Gender identities and discourses are produced simultaneously with science and technologies. Neither pre-exists the other. Gender is material, discursive, and social; it permeates artifacts, culture, and social identities.
- Technologies play an important role in constructing the identities of users and vice versa.

Problems

- Does not offer scientists and engineers clear methods.

Policy implications still valid

- Understanding that gender and science/technology are deeply interrelated.

Gendered innovations

This approach (2000-present) employs gender analysis as a resource to stimulate creativity in science and technology, and by doing so to enhance the lives of both men and women.

Basic tenets

- Employs gender analysis as a resource to enhance scientific excellence.
- Mainstreams methods of sex and gender analysis into basic and applied research.
- Refutes the notion that increasing women's participation will automatically lead to gender-sensitive science and technology. Everyone –men and women– can and must be trained in sophisticated methods of sex and gender analysis.
- Examines intersections of gender, race, nationality and ethnicity.
- Seeks methods of sex and gender analysis relevant to both Western-style and local knowledge.

Gender mainstreaming entails the systematic integration of gender equality into all systems and structures, policies, programmes, processes and projects, into ways of seeing and doing (Rees, 2002). Gender mainstreaming now needs to be expanded to include gender analysis in basic and applied research in science, medicine and engineering.

Mainstreaming gender analysis into research creates 'gendered innovations'. Gendered innovations use gender as a resource to create new knowledge. It is crucially important to

identify gender bias and understand how it operates in science and technology. But analysis cannot stop there: focusing on bias is not a productive strategy. Gender experts in science and technology are now shifting the emphasis away from critiques and toward a positive research programme that employs gender analysis as a resource to stimulate gender-responsible science, medicine and technology (Faulkner 2001, Klinge 2008, Schiebinger 2008a, Wajcman 2007).

In order to mainstream gender analysis into basic and applied research, there is a need for gender experts, working with scientists and engineers, to develop internationally agreed upon methods of sex and gender analysis that can serve as a baseline for understanding how gender functions in research. It is not enough simply to 'add on' a gender component late on in the development of a given project. Research must consider gender from the beginning (WHO, 2010). Designing sex and gender analysis into basic and applied research requires that researchers be trained in specific methods, so that they can address gender issues where appropriate.

Methods of sex and gender analysis for science, medicine and engineering are only now being developed. Gender theory has had enormous impact in the humanities and social sciences over the past thirty years and is increasingly being integrated into medicine and the life sciences. To develop methods of sex and gender analysis, gendered innovations draw from the best gender theorists of the past thirty years. Peggy McIntosh, for example, presented an early (1983) model of progress in science from a 'womanless science' through a stage that advocated adding women to 'science as usual' to a stage that looked at things from the 'female point of view'. Hilary Rose (1994) urged scientists to engage in equal measure 'hand, brain and heart'. Science

theorists Donna Haraway and Sandra Harding called for adding a greater understanding of social context to scientific research: Haraway's 'situated knowledge' (1988) and Harding's 'strong objectivity' (1991). Philosopher Helen Longino (1990) explicated how background cultural and social assumptions shape science. Technology theorists Judy Wajcman and Nelly Oudshoorn demonstrated how gender relations 'materialise' in various technologies, that is to say, how gender identities and technologies are 'coproduced', or mutually shape one another (Faulkner, 2001). What is needed now is to distill and translate these often complex insights into methods readily usable by scientists and engineers. Projects to develop such methods are currently underway in Canada, the United States and Europe.⁶ Yet, there is a need to develop internationally agreed upon methods of sex and gender analysis as recommended in the 2010 genSET *Consensus Report* (genSET 2010)

and the 2010 United Nations Expert Group on Gender, Science and Technology (UN, 2010). Internationally standardised methods of sex and gender analysis must work across local knowledge systems as well as Western-style sciences and institutions.

Problems

- Methods of sex and gender analysis are only now being developed in an international context.
- Scientists, engineers, and policy makers are not yet trained in methods of sex and gender analysis.
- Methods of sex and gender analysis are not yet mainstreamed into curricula from primary through tertiary S&T education.

Recommendations for addressing these problems are presented in the final chapter of this synthesis report.

Box 38. Methods of sex and gender analysis

Methods of sex and gender analysis serve to enhance science excellence. The methods listed here represent a minimum set of issues that researchers should consider. As with any set of methods, researchers will fine tune methods to their specific enquiry. The value of these methods depends, as with any intellectual endeavor, on the talent and creativity of the research team.

1. Analyzing gender
2. Analyzing sex
3. Analyzing covariates
4. Formulating research questions/Envisioning design
5. Analyzing research priorities and potential outcomes
6. Redefining key concepts

⁶ See *What's Sex and Gender Got to Do With It? Integrating Sex and Gender into Health Research* (CIHR, 2003) from the Canadian Institute of Gender and Health. In 2009, the Clayman Institute for Gender Research at Stanford University initiated *Gendered Innovations in Science, Medicine, and Engineering Project*. This project will expand through a collaboration with the European Union Unit for Scientific Culture and Gender Issues beginning in 2011.

7. Sampling
8. Analyzing standards and reference models
9. Analyzing language and visual representation
10. Rethinking theory
11. Analyzing academic disciplines
12. Analyzing knowledge created through gendered divisions of labour

Schiebinger, L., Klinge, I., Arlow, A. & Newman, S. 2010, 'Introduction' in L. Schiebinger and I. Klinge, eds. *Gendered innovations. Mainstreaming sex and gender analysis into basic and applied research. Meta-analysis of gender and science research – Topic report*. Downloaded on 16/11/2010, available at:

http://www.genderandscience.org/doc/TR6_Gendercontent.pdf

3.2.2 *Biomedical and health research*

This section provides readers with a historical overview of the contributions of feminist scientific research and critiques as they relate to the fields of biomedicine and health between 1980- 2010. It identifies critical frameworks of analysis developed by feminist scientists to investigate gender bias in biomedical research. Moreover, it reviews newly emerging feminist frameworks that seek to apply feminist concepts, such as sex, gender, and intersectionality, to biomedical and health research so as to open new lines for understanding the biological body and create innovative prevention models for health policy. The section also provides a brief overview of significant policy developments in Europe that have served to counter gender bias in publicly financed research and promoted research innovations using sex and gender analyses. Although feminists have had significant impact on the social sciences, many feminist concepts such as sex, gender and intersectionality are just beginning to be introduced into the natural sciences. The majority of this section, therefore, focuses on emerging efforts to translate feminist concepts

into practical methods and research tools for those working and conducting research in the field of biomedicine.

Three distinct frameworks have emerged over the last thirty years to investigate sex and gender bias in biomedical and health research. Influenced by the second wave feminist movement's efforts to make women's lives and experiences a relevant topic for scientific research, the first framework employs Sandra Harding's (1991) concept of 'strong objectivity' to methodically investigate what biomedical research has to say about women. In doing so, feminist scientific pioneers such as Bleier (1984), Fausto-Sterling (1985), Fox Keller (1985) and Hubbard (1990) and contemporary feminist scientists such as Fine (2010), Nicolson (1995) and Taylor (2006) demonstrate how normative notions of gender, particularly of women, have distorted scientific research priorities, designs and interpretations of results. The second framework represents the turn to post-modern theory and its textual critiques, specifically how the language used by biomedical and health researchers to access and observe the world is embedded with cultural assumptions and normative ideas about gender and sex. Feminist researchers,

such as Martin (1991), Oudshoorn (1990), Roberts (2007) and Spanier (1995), expose what Donna Haraway (1988) terms the 'partial perspective' of scientific researchers and (re)examine biological knowledge claims that read normative notions of gender into the biological body. By doing so, these feminist scholars help to create a conceptual space to re-theorize and re-visualize gendered and sexed bodies. The final framework has only recently been emerging and seeks to move beyond critique and provide scientific researchers with the conceptual tools to effectively consider sex and gender issues in biomedical research projects. Feminist scientific researchers, such as Nieuwenhoven and Klinge (2010), explain that biomedical researchers can apply the principles used in the social sciences to avoid gender bias in research practices and by doing so improve the reliability and accuracy of the research. Moreover, Londa Schiebinger (2008a) demonstrates that when the feminist concepts of gender and sex are used rigorously and creatively, what she terms new 'gendered innovations', which have the potential to enhance scientific knowledge and understanding, are produced.

Overall, literature shows that there is much to be gained by taking seriously feminist critiques and attempts to translate theoretical concepts such as gender, sex and intersectionality into biomedical and health research practices. This review captures the initial stages of this cross-disciplinary collaboration. Although much work is needed to further develop these concepts into innovative methodological tools for biomedical and health research and address the gaps in research, current research provides a foundation and the intellectual tools needed for new research designs, new questions and new interpretations. To ensure that the utility of these concepts will not continue to be ignored, leadership is required on the part of funding agencies, journals, and curriculum developers to see to it that these

concepts are considered in all biomedical and health research activities. The persistence of sex bias in biomedical and health research can be brought to an end, and new innovative lines of research can be opened if researchers are required to work collaboratively to integrate the concepts of sex, gender and intersectionality into their work.

The concept of sex

In the June 2010 issue of the highly influential biomedical journal *Nature* an editorial was published addressing the persistent sex bias in biomedical clinical and basic research and its detrimental impacts on human health. This sex bias takes the form of excluding female human subjects and the total exclusion of pregnant female subjects from clinical research and/or the failure to analyse sex differences between male and female subjects. Sex bias is also prevalent in animal research, which means that female animal models are not used in the development of numerous disease treatments. The need to address sex bias in biomedical research has become even more imperative as researchers discover various sex differences in disease onset, prevalence, and symptoms. The concept of 'sex' has traditionally been defined as those biological characteristics that distinguish males and females. In human beings, sex differences, such as differences in reproductive organs, body size and shape and the different levels of hormones circulating in the body, are thought to derive from basic chromosomal differences in which females have two X chromosomes and males have one X and one Y. Feminist and queer researchers in the social sciences, drawing from the experiences of intersex and transgender populations, have questioned this dichotomous two-sex model. This critique has led to the development of a more fluid conception of sex that allows researchers to investigate the biological body with a new lens and account

for variations in the biological that they have previously missed or ignored. Moreover, it directs biomedical researchers' attention to the various biological factors that must be controlled for when testing or researching sex differences rather than simply adding female subjects.

The concept of gender

Feminist researchers have documented how sex and gender are often used interchangeably and how the meaning of gender is conflated with that of sex in mainstream biomedical and health research. Consequently, the impacts of the gendered social environment are under-researched and differences in health outcomes are assumed to derive from biological differences between men and women, foreclosing any analysis of the social causes of health differences. Feminist health researchers have demonstrated that a sex analysis is insufficient for understanding differences in health and illness between men and women. The concept of gender directs researchers' attention to how men's and women's lives and health are shaped by multiple and unequal gender relations and, in doing so, provides contributing factors that explain sex differences in various diseases. Hence, incorporating gender into biomedical research requires the adoption of a new paradigm for scientific inquiry that is based on an alternative conception of the biological body, shaped by complex interactions with the social environment. A gender analysis expands understandings of mechanisms that cause differences in disease symptoms, outcomes, and susceptibility with the aim of producing more focused and accurate treatment. Gender operates at various levels, namely the individual, institutional and policy levels, to shape men's and women's health behaviours and exposures to illness. Although it is difficult to compartmentalise the social world, analysing gender relations at various

levels has proved to be an effective method for distinguishing the various social impediments that have an impact on the health of men and women.

This section focuses primarily on advances made in developing three levels of gender analysis and how they can be adopted by biomedical and health researchers to better understand the impact of gender on health. It starts with a focus on the individual level and explains that individual behaviours, including health related behaviours, both reproduce gender norms and reflect individual efforts to achieve or resist identification with culturally established gender ideals. This framework shows the lack of research done on the subject, particularly in relation to women, and encourages health researchers to conduct qualitative research studies that capture how ideals of masculinity and femininity impact the various health-related behaviours of individual men and women. The second level of analysis is the institutional level and explains that feminist researchers have documented how institutional policies and practices have been shaped by ideas of gender and therefore put different constraints on the health choices of men and women. Three different types of institutions, namely medical institutions, workplaces, and neighborhoods, are provided as examples in which feminist researchers have identified distinct unequal gender structures which, preliminary research suggests, have uneven impacts on the health of men and women. This framework provides researchers with analytical tools to address gaps in research and systematically analyse the gendered health impacts of institutional policies, practices and structures on both men and women. The final level of analysis is the policy level, in which feminist researchers have successfully adapted the regime typology model to correct the gender blindness in comparative policy research. These researchers have shown that public policies that determine labour standards, access to social security benefits and paternity

and maternity leave shape gender relations and men's and women's everyday lives. Patterns of health, illness and diseases among men and women vary among countries, indicating that different policy regimes have particular gendered effects on health. Recently, a study (Bambra et al., 2009) has shown how this framework can be extended into the field of health research to systematically compare and describe the gendered health impacts of national welfare policies. By analysing the impact of gender at the various levels of social organisation, it is hoped that researchers can develop a better understanding of how various social factors impact the health of men and women and develop targeted responses to address them.

Intersectionality

Recently, some feminist health researchers have begun to adopt an intersectional framework in an effort to make visible the perspective and needs of women and men who remain invisible under mainstream gender analyses. Feminist health researchers have been careful to distinguish the intersectional approach from the co-variate approach, which is often adopted by most mainstream biomedical and health researchers. The co-variate approach typically assumes that categories such as gender or race are independent analytic categories that can simply be added together and compared and often use concepts such as race, gender, class, and sexual orientation uncritically as indicators of biological or cultural differences between human beings. The intersectional perspective probes beneath single identities markers to account for the complex set of social relations that produces them. Moreover, conceiving these concepts as unequal social relations allows researchers to consider how various inequalities operate, intersect, overlap, and reinforce each other to produce health disparities, rather than simply describe health

disparities between or among assumed separate groups. Hankivsky et al. (2010) explain that the models and methods of measuring and investigating multiple intersectionalities are only in their infancy and have yet to be fully developed. A mixed methods approach of qualitative and quantitative interdisciplinary research is recommended to produce intersectional research that can pinpoint how multiple and intersecting social relations affect women and men in their daily lives and interact in specific situations to condition health. It is hoped that the intersectional framework can provide researchers with the analytical tools needed to move beyond descriptive quantitative research that fails to explain why or how disparities in health exist and start producing directive research that can identify the policy changes needed to transform inequities in health.

3.2.3 *Engineering and technology*

Research has identified the gendering of engineering and technology as masculine as a key explanation for the low numbers of women in those fields. In the Western world, technology has historically been associated with industrialisation, transportation, and the military, and this has contributed substantially to the gendering of technology (Wajcman, 2010). An 'aggressive', 'crude', and sometimes 'swaggering' masculinity grew alongside this physically arduous, often dirty and dangerous work (Oldenziel, 1999).

The information technology (IT) revolution did not break the association between technology and masculinity (Gansmo et al., 2010). Even though women were the original 'computers', performing precise calculations before the advent of electronic computers, decidedly male 'hackers' and 'geeks' were identified as driving early digital computing. This distinctive masculinity was associated with a culture of lonely, isolated, and socially inept 'nerds'

Box 39. Consequences of the association between masculinity and technology

- **Stereotypes limit workforce diversity and global competitiveness:** Stereotypes that exclude women necessarily also exclude particular knowledges that women have developed through gendered divisions of labour.
- **Stereotypes reinforce narrow definitions of masculinity:** Men as a group are not homogenous –there are many forms of masculinity, and these differ by region, religion, class, national culture, and other key social factors. Associating engineering and technology with one form of masculinity limits creativity and innovation.

Schiebinger, L. & Arlow, A. 2010, 'Engineering and technology' in L. Schiebinger and I. Klinge, eds. *Gendered innovations. Mainstreaming sex and gender analysis into basic and applied research. Meta-analysis of gender and science research – Topic report*. Downloaded on 16/11/2010, available at: http://www.genderandscience.org/doc/TR6_Gendercontent.pdf

engaged in extreme programming and math (Turkle, 1984).

Scholars emphasise, however, that the masculine image of information technology is pervasive but not universal. At the University of Malaysia, for example, women made up 53% of undergraduates in computer science and 64% in specialised IT programmes (Othman & Latih, 2006). Vivian Lagesen has shown that students in Malaysia consider IT a good field for women and do not describe it to be 'masculine' (Lagesen, 2007).

Efforts are currently being made to change engineering stereotypes as the field itself changes. Wendy Faulkner has emphasised that while engineers were once trained on the shop floor, where physical strength was an advantage, modern engineering requires more 'brain' –a combination of technical and interpersonal skills–than 'brawn' (Faulkner, 2006). As a result, a number of organizations, including the US National Academy of Engineering and the International Institute of Electrical and Electronics Engineers (IEEE), are seeking to remake the image of the engineer to encourage

girls and women to choose courses of study that lead to engineering degrees (US National Academies, 2010; IEEE, 2008).

Women as designers

Difference feminism in the 1980s and 1990s commonly held that women 'do science differently' or that there are 'women's ways of knowing' (Goldberger et al., 1996). It is true that gendered divisions of labour mean that including women in engineering may bring new perspectives, priorities, and ideas. Workforce diversity is important, but does not, in and of itself, guarantee innovation or gender-responsible design. Neither women nor men are immune to gender bias, and an interest in 'women's issues' does not automatically translate into expertise in gender analysis.

Volvo's Your Concept Car (YCC), developed in 2002, was the first concept car designed by an all-female team (Temm, 2008). In concert with difference feminist thinking, the car was designed 'by women and for women' –in this case, female luxury car buyers. Scholars have

shown that certain features of the YCC, such as a hood (or bonnet) that allowed no access to the engine for maintenance, tend to reinforce gender stereotypes (Styhre et al., 2005). The sales motto for the YCC – ‘If you meet the expectations of women, you exceed the expectations of men’ – suggests that women are inherently ‘more demanding’ than men. Finally, the YCC project has been revealed as a form of tokenism, whereby Volvo made temporary concessions to women while ignoring deeper issues. Volvo employees reported that the project had little internal influence. One interviewee described ‘a huge disconnect between how much attention it [the YCC project] generated externally and how little influence [it had] internally’ (quoted in Elmquist, 2007).

The co-construction of gender and technology

The late 1980s saw the development of co-constructionism, a scholarly approach to technology that continues to produce fruitful insights. Co-construction was developed to avoid the dual problems of: 1) gender essentialism – the notion that ‘fixed, unified, and opposed’ female and male natures influence technological development and 2) technological determinism – the idea that the inevitable march of technology shapes gender roles. Co-constructionism, by contrast, emphasizes that gender and technology are ‘co-constructed’; that is to say, technology shapes gender relations while, at the same time, gender relations shape technology. Faulkner writes that technology is ‘both a source and consequence of gender relations and vice versa’ (Faulkner, 2001). In a similar vein, Judy Wajcman notes that ‘gender relations can be thought of as materialized in technology, and gendered identities as produced simultaneously with technologies’ (Wajcman, 2007). In other words, people and artifacts co-evolve. Neither gender nor technology is

taken to pre-exist; both are malleable and subject to change.

Nelly Oudshoorn provides a prime example of co-constructionism in *The Male Pill*. The female birth control pill was constructed by gender: women ‘need’ contraception more than men because women often have less control over sex and yet greater responsibility for unintended pregnancies. At the same time, technology reinforces gender roles: the existence of the female pill and the non-existence of a male pill reinforces the idea that reproduction is a woman’s responsibility (Oudshoorn, 2003).

How users matter

Users are often considered passive consumers of technology: in this view, inventors or designers create technology; consumers use whatever is produced. More recently, technology studies have shifted away from a traditional focus on the artifact (design) and engineer (designer) to focus on users and their roles in the development of technologies. Oudshoorn and Pinch have argued that feminist scholars have played a leading role in these developments (Oudshoorn & Pinch, 2003).

Susanne Maass and Els Rommes show how taking users into account has revolutionised software for customer-service and marketing call centers. In so doing, they shed light on the ‘productivity paradox’ – the phenomenon that new technologies often lead to a drop in productivity (Maass & Rommes, 2007). They found that mainstream call-center software supports stereotypically ‘masculine’ functions (gathering and dispensing information) but not stereotypically ‘feminine’ functions (interacting with customers and understanding their needs). Using techniques of participatory research, Maass and Rommes observed, interviewed, and worked with call center employees to understand their needs.

Analysing gender led to new call center software that also supports agents' interactive work with customers, ultimately allowing agents to provide friendly, flexible service. Gender analysis has produced software that is better received by users and boosts productivity.

User-centered design is now routine in many industries. Increasingly, user-centered design involves considering women, whose education levels, earnings, and buying power have risen dramatically in recent years. The Danish government, for example, has funded *Female Interaction*, a programme devised to make Danish industry more competitive by promoting user-driven innovation (Schroeder, 2010). In Germany, the Fraunhofer Institute, Europe's largest application-oriented research organisation, developed their project, *Discover Gender*, with much the same purpose (Schraudner & Lukoschat, 2006). In both instances, the goal is not to have products designed 'by women, for women' (as in the case of the Volvo YYC) but to set out design principles, strategies, and guidelines that all designers –men and women– can use to better serve all users.

Rethinking theory: redefining technology

Gender studies of technology have broadened the definitions of technology from 'heroic' technologies associated with the military and industry (such as steam engines, automobiles, suspension bridges, and space stations) to include 'everyday' objects, such as washing machines, microwaves, braziers, and vibrators (Bray, 2007).

Research has also brought to light artifacts previously discounted as insignificant and hence hidden from history. Rachel Maines (1998), for example, has explored the history of vibrators within the contexts of medical

practice and women's personal use. Historically, physicians recommended orgasms as a treatment for 'hysteria,' a disease thought to affect about 75% of all women. As early as 1752, engineers produced time-saving medical equipment to aid physicians in bringing their female patients to orgasm. These included 'hydrotherapeutic appliances' that provided stimulation with jets of warm water. Mechanical vibrators were also common. Some were 'wind-up' types; others were continuously powered by foot pedals or, later, even by steam engines. Engineers incorporated emerging technologies quickly: electrically-powered vibrators tethered to massive batteries became available even before widespread electrification. Similarly, Sharra Vostral and others have examined the technological history of menstrual products as 'hidden artifacts', often excluded from the everyday definition of technology (Vostral, 2008). Judith McGaw (2003) has examined the brassiere as one of the many feminine technologies about which technological history tells us virtually nothing. Focusing on women's lives and, at times, inventions, has contributed to retheorizing what technology is and how it functions in society.

Gendered innovations

Mainstreaming sex and gender analysis into research creates 'gendered innovations'. Gender bias in research limits the potential benefit of science and technology to society. It is important to identify gender bias and understand how it operates in science and technology. But analysis cannot stop there: focusing on bias is not a productive strategy. Gender experts in science and technology are now shifting the emphasis away from critique and towards a positive research programme that employs gender analysis as a resource to stimulate gender-responsible science and technology. As stated above, methods of sex and gender analysis for science,

medicine, and engineering are now being developed. The following section provides short case studies that apply these methods.

Example 1. Pregnant Crash Test Dummies



'Linda' by Volvo, the world's first virtual pregnant crash-test dummy

a. The problem: Conventional seat belts do not fit pregnant women properly, and up to 75% of fetuses may be injured in a 35mph frontal crash.

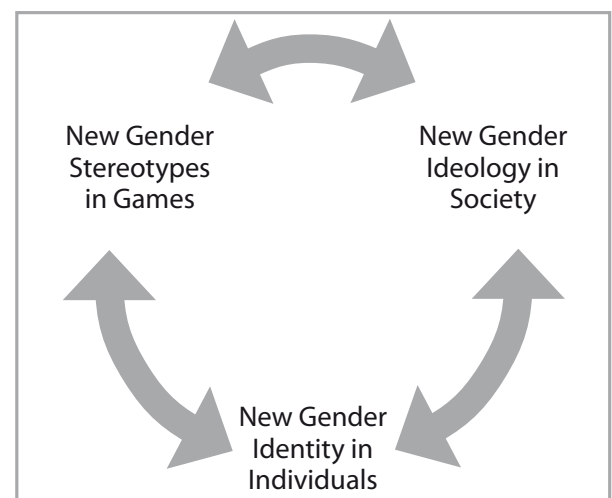
b. Key method of analysis: Analysing reference models: In much of technology design, men are taken as the norm; women are analysed as an afterthought and often studied from the perspective of how they deviate from the norm. This means that women may be left out of the 'discovery' phase –as a result, many devices are adapted to women retrospectively, if at all. In this case, the three-point seatbelt was designed with no attention to pregnancy.

c. Gendered innovations: Solutions to safety testing are emerging from Sweden. Volvo's 'Linda', designed in 2002 by mechanical engineer Laura Thackray, is the world's first computer-simulated pregnant crash-test dummy. 'Linda' generates data modeling the effects of high-speed impact on the woman and fetus. Automobile manufacturers,

however, have yet to introduce an alternative to the 3-point seat belt.

d. Further comments: Using methods of sex and gender analysis from the beginning would have helped engineers to avoid leaving out the safety of the fetus. Taking both men and women as the norm may expand creativity in science and technology –from the start, devices should be designed for a broad population. Policy needs to keep pace: Even today, few nations use pregnant crash-test dummies in government-mandated automobile safety testing.

Example 2. Video Games



Games may provide a cultural space for experimentation with gender

a. The problem: Over the past 50 years, men have dominated the video game industry, both as inventors and players. Gaming is often the first step towards a career in information technology, and is increasingly used in education, job training, communications, and medical rehabilitation. Moreover, because games immerse players in interactive and compelling stories, they can shape behaviours, social values and gender norms.

b. Key method of analysis: Rethinking visual representation: Co-constructionism leads to an understanding of how games (like songs,

movies, literature, and other media) simultaneously reflect and influence social behaviour.

c. Gendered Innovations: Analysing gender has led to understanding how games might provide a 'safe-zone' where designers and players can explore and relearn gender identities and behaviours. Games may serve as a catalyst for change –in gender ideologies, social equality and in the gaming industry itself.

d. Further comments: While recognising the transformative potential of video games, scholars also emphasise the dangers of these worlds. *Second Life*, for example, is a sophisticated 3D space where users create avatars, homes, and entire lifestyles using in-world currency, yet it is also a major source of virtual pornography and can promote sadomasochistic forms of sex.

Example 3. Civil Engineering to Secure Water Supplies

a. The problem: Millions of people worldwide lack reliable, efficient access to water.

b. Methods of analysis: Analysing social divisions of labour helps researchers to understand who in a community holds the knowledge required for a particular project. Women, as traditional water fetchers, often have specialised knowledge concerning water sources. Participatory research calls for users with specialised knowledge to be engaged in development projects from the start.

c. Gendered innovations: Social divisions of labour in much of Africa make water procurement women's work. Consequently, women have detailed knowledge of soils and their water yield. Civil engineering teams deciding on well placement found that tapping into women's knowledge provides the best water yields. A study of water projects in

88 communities showed that the most successful 15% of projects involved high levels of participation by both women and men. The least successful 15% of projects were those that excluded one sex. Including women in democratic decision-making more than doubled the chance of a project being ranked in the top 15% of projects (Gross et al., 2001).

3.3 Policies towards gender equity in science

This chapter presents an overview of the literature dealing with the evaluation of, and comparison between, policies towards gender equity in science,⁷ on the basis of the meta-analysis carried out by Castaño et al. (2010). We were especially interested in fleshing out the impact and practical consequences of these measures on the situation of women in science and research as well as on gender dimensions in research content. It is important to point out from the outset that this does not include an exhaustive and detailed overview of the existing gender and science policy situations across Europe. Others have done this sufficiently (Rees et al., 2002; Ruest- Archambault et al., 2008; EC, 2008; EC 2009b).

Gender equity policies in science have become an important issue in all EU member states. Apart from Equal Treatment laws, many countries have also passed 'gender mainstreaming' legislation and integrated these into administrative procedures. Several countries have also devised direct support

⁽⁷⁾ Although gender *equality* and gender *equity* are often used interchangeably in the literature, we conceive the importance of policy to encompass not only the liberal notion of 'equal' opportunities but also 'equal' constraints. Whereas equality refers to equal resources/opportunities (equal pay, access to opportunities, freedom from harassment), equity takes into account the wider socio-economic conditions under which given people have to perform (constraints have to be accounted for). Policies for providing equitable situations for women and men in science should comprise equal opportunities and equal constraints.

measures, such as improved child care or specific mentoring programmes. As the EC report (Ruest-Archambault et al., 2008, pp. 42-43) on *Benchmarking Policy Measures for Gender Equality in Science* demonstrates, most member and associated countries of the European Union have a Ministry for Women's Affairs / Statutory Gender Equality Agency. However, when it comes to a commitment to mainstreaming or specific Women in Science Units and committees, or even such elementary services as collecting sex-disaggregated statistics, a far patchier picture emerges. The variety of policy measures and the persistence of unacceptably high levels of inequalities (related to pay, funding, career possibilities, etc.) across most EU countries, make it urgent to examine the effectiveness and impact of these policy measures.

A central reference in this undertaking is the already cited *Benchmarking* report (Ruest-Archambault et al., 2008). By correlating key national policies targeting women and science with national statistical profiles, the authors hope to identify the 'main drivers of progress towards gender equality' (p. 14). This presents two real difficulties. First, it is problematic to establish clear-cut relations between certain policy measures and the overall representation of women in science. Besides the lack of time-series data to assess the long-term impact of policies, specific measures always form part of a wider social context that makes it hard to attribute change to a single source. Second, some of the policies or measures examined showed no statistically significant correlation with the proportion of women in science. As the authors argue, however, this should lead to a more thorough examination of measures and initiatives below the national level. Local and small-scale initiatives could have a more decisive impact on women's participation in science than large-scale programmes.

Although the *Benchmarking* report establishes a first guiding framework for the correlation

between certain national policies and their effectiveness for gender equality in science, the meta-analysis carried out provides additional material. The incorporation of national literature and, above all, small-scale evaluation reports allows for a more detailed assessment of the quality and potential impact of these gender policies and programmes. In addition to an analysis of the presence or absence of certain policies, the study was meant to capture the more qualitative aspects of these measures as expressed, for example, through the opinion of the participants. From the available literature we also expected to obtain new insights into the transferability of these policies and thus identify context-sensitive factors of success from more general aspects driving gender equity in science. The first section of this chapter presents the conceptual dimensions of the meta-analysis carried out, whilst the second deals with the results of the analysis of the relevant literature on policy evaluation, which is grouped according to three main themes: (1) measures towards advancing women's science careers; (2) science management and reform, and (3) the gender dimension in research and higher education.

3.3.1 Policy analysis

What emerges from the literature is a general lack of concrete evaluation of policy measures towards gender equality in science when compared to the variety of measures in place. Except for a handful of large-scale (both in time and thematic depth) studies, concrete evaluations and reports on the outcomes of these policy measures are suspiciously absent. Most of the literature revised is either descriptive of the general underrepresentation of women in science or indulges in theoretical reflections on the validity of the desired policy objectives. Some, however, do incorporate concrete, empirically sound evaluations. The lack of empirical research on policy for women

and science, therefore, requires an initial mapping of the terrain from a more conceptual perspective. By crossing the literature on the evaluation of public policy with the available policy instruments and objectives, we establish a grid of theoretical approaches. This will allow us to identify the dimensions of the meta-analysis and the gaps in the literature that would otherwise be difficult to perceive.

Policy contexts

Despite many EU initiatives and policy directives, national frameworks of R&D and social policy crucially determine the overall conditions of women in science and research. A wide variety of historical developments and national policy settings can be observed across the EU that shape and influence the roll-out of policy towards gender equity in science and research.

Cozzens (2004) distinguishes between three large policy fields in science and technology, namely (1) research policies, (2) innovation policies that stimulate the development of new products and processes, and (3) human resource policies. The most common form of policy for equity in science and research both in the US and in Europe is found within the human resource approach. The key indicator of success here relates to the proportional participation of women in all areas of the science and research system. However, despite the fact that Cozzens distinguishes between these different policy domains, it is important to note that advancement in gender equity is a result of the combined effect of the R&D and innovation systems, the relevance of science for the national economy, the features of the labour market, and the equity policies in place in addition to the policy instruments and agents used.

The *Benchmarking* report (Ruest-Archambault et al., 2008) clusters countries on the basis of

the gross domestic expenditure on R&D per R&D personnel. Two large country groups can be distinguished, specifically 'higher vs. lower systems of innovation'. Within the first group, the *European Innovation Scoreboard* (UNU-MERIT, 2008) further distinguishes between the 'innovation leaders' such as Sweden, Switzerland and Germany and the 'innovation followers' such as France, the Netherlands, Belgium and Austria. Within the 'lower systems of innovation' we find the 'moderate innovators' (e.g. Czech Republic, Italy, Norway, Spain) and the 'catching-up' countries (e.g. Bulgaria, Greece, Hungary, Poland, Portugal, Romania, Slovakia) (see table 8).

Instead of foregrounding the expenditure on R&D personnel, *The Gender Challenge in Research Funding* (EC, 2009b) report proposes a slightly different but nevertheless instructive classification based on the general gender equality context in each country (see table 9). Thus, countries are roughly divided into proactive ones, which promote and monitor gender equality in research with active policies and measures, versus comparatively inactive countries that display few such measures and initiatives. Within the proactive countries, three important sub-groups are established: Finland, Norway and Sweden belong to the 'global gender equality leaders'. These Nordic welfare states are characterised by early (from the late 1970s-early 1980s onwards) committed efforts to embed gender equality into science policy and society at large. A second proactive group comprises 'newly active countries with traditionally fewer women in research' such as Germany, the Netherlands, Austria, Belgian Flanders and Switzerland. In recent years, these countries have developed a very active policy agenda in order to address the below-average (EU) representation of women in science. And third, the proactive countries also include 'newly active member states with more women in research' such as Spain, the UK and Ireland.

Table 8. Classification of countries based on *European Innovation Scoreboard*

Above EU27 Average Summary Innovation Index (SII) Score		Below EU27 Average Summary Innovation Index (SII) Score	
<i>Innovation Leaders</i>	<i>Innovation Followers</i>	<i>Moderate Innovators</i>	<i>Catching-up</i>
Denmark Finland Germany Israel Sweden Switzerland UK	Austria Belgium France Iceland Ireland Luxembourg Netherlands	Cyprus Czech Republic Estonia Italy Norway Slovenia Spain	Bulgaria Greece Lithuania Malta Poland Portugal Slovakia ... among others

Source: UNU-MERIT (2008).

Table 9. Classification of countries based on *The Gender Challenge in Research Funding*

Gender equality leaders, small gender gap, more women in higher education research (Group 1)	Newly active countries, few women in higher education research (Group 2)	Newly active countries with more women in higher education research (Group 3)	Relatively inactive countries, some with more women in higher education research (Group 4)
Finland Norway Sweden Iceland Denmark	Austria Belgian Flanders Germany Netherlands Switzerland	UK Spain Ireland	Bulgaria, Croatia, Czech Republic, Cyprus, Greece, Estonia, Hungary, Israel, Italy, Luxembourg, Malta, Poland, Portugal, Romania, Turkey

Source: EC, 2009b.

Reading both EC reports together establishes an interesting cross-section concerning our meta-analysis. As the *Benchmarking* report contends, 'countries which have high levels of women researchers are less likely to have policies for women in science' (Ruest-Archambault et al., 2008, p. 20). This is true for the Nordic welfare states –the gender equality leaders– where the relatively high participation of women in science can be considered a result of its early and comprehensive treatment of gender issues

across all policy areas. Pettersson (2007) writes in this regard that in Finland and Denmark, the high participation of women in the labour market is taken as an indicator of the achievement of gender equity. Gender is thus deproblematized and consequently not present on the policy agenda. But an even higher percentage of women in science is found in 'catching-up' countries, which have few policies and low R&D personnel expenditure (Ruest-Archambault et al., 2008, p. 25). Rather than reflecting the results of

recent gender policy intervention, the relatively high percentage of women in the science and research sector can be understood as a result of the equal integration of men and women into the workforce (Miroiu, 2003).

This picture of the relation between the presence/absence of broader equity policies and women's participation in research illustrates a specific pattern that emerges in the review of the literature. There are relatively few publications dealing with empirical research on policy on equity in science from the Northern countries and the new Eastern European member states. Due to very different (historical) reasons, there are either few policies to do research on or the issue of gender is (no longer) perceived as problematic. In contrast, the most abundant literature can be found in those countries which are innovation leaders but have below-average representation of women in science. Germany, Austria and Switzerland in particular have developed many national initiatives to increase women's participation at all levels of the science and research system. These three countries provide the most thorough and comprehensive body of literature on policy on gender equity in science. Evaluation and accompanying research are a crucial element of these structural initiatives and much of the reviewed literature on concrete evaluation experiences and their impact is found across these European countries. Finally, among those countries which have recently become more active in policy on gender equity (UK, Ireland and Spain), one might expect to see a growing body of literature concerned with the evaluation of their measures, which is currently still lacking.

Apart from the relative importance of public policy on gender equity in science and research it is important to remember that 'the main factor, which negatively influences the female proportion of researchers, is the relative size of the business enterprise R&D

sector' (Ruest-Archambault et al., 2008, p. 27). Countries with large private business R&D sectors have lower proportions of women researchers than countries with smaller business R&D sectors. This means that innovation policies (in contrast to human resources policies) which are directed towards stimulating the development of new products and processes in the private sector are an area which is especially under-researched despite its strategic importance for questions of gender equity.

Legislation approaches

Legislation can affect the position of women in science in two main ways. Firstly, it can prevent discrimination (for example, equal pay and recruitment) and secondly, it can promote positive action (for example, quotas and networks).

Equal opportunities legislation can affect the participation of women in science by preventing and sanctioning discrimination based on sex and is present in all countries studied in the *Benchmarking* report (Ruest-Archambault et al., 2008, p. 29). Legislation relating to equal pay and the reduction of the wage gap are important tools in the push for gender equality in science. Various countries have included equal opportunities issues into the legislation regulating higher education, including the financing of universities (Rees et al., 2002, pp. 22-23).

Legislation as regards positive action has also been developed; for example, some of the Nordic and Southern EU member states in particular employ quotas and targets to create an impact on gender balance in public bodies and scientific committees. Such legislation has been found to have had a significant effect on the proportion of women found on senior university and research institute committees, research councils, selection panels etc. At the

national level, most countries have a ministry for women although the impact of its presence/absence on women in science is difficult to evaluate (Ruest-Archambault et al., 2008, p. 29).

The literature in the GSD evaluates different legislative approaches and their shortcomings to increasing the representation of women in science in different contexts within Europe. By examining these within the different approaches to gender equality, we can begin to paint a comprehensive picture of the literature regarding how legislation helps to advance the position of women in science.

Booth and Bennett's (2002) approach to gender equality as three related perspectives

is useful to distinguish analytically between the dominant trends and their legal implications (see box 40).

The equal treatment perspective was the dominant legal framework of most European countries that regulated women's presence in science until the 1970s and is comprised of actions that guarantee women the same rights and opportunities as men in the public sphere. Its delivery mechanisms are through statutory and mandatory legal instruments. Rees (2005) terms this approach 'tinkering'. The foundations of this approach were laid in the 1957 Treaty of Rome and put into effect in the 1970s when high-profile legal challenges invoked the equal treatment of

Box 40. History of gender equality

The history of gender equality is usually divided into three distinct phases that coincide with the evolution of feminism. The first wave of feminism is linked to campaigns for women's suffrage rights. This trend is characterised by liberal principles of equal rights and treatment before the law. The second wave predominant in the 1960s can be linked to a growing demand of feminists above all for positive action and separate women's provision. From the 1990s, this wave shifts to the gender perspective highlighting gender relations which recognise the rights of both women and men, stressing the need for equal work and the involvement of men in the process of change.

Timeline of gender equality		
1st Wave 1918	2nd Wave 1960	3rd Wave 1990
Equal Perspective	Women's Perspective	Gender Perspective
Equal rights & opportunities	Equality outcomes	Equal but different
Legislative response	Separate institutional provision	Managing diversity

This linear explanatory model is difficult to apply (even in countries like the UK, France, Germany or the US) as it neither reflects the complexities of the struggle nor the progressive mechanisms of change. This conceptualisation goes some way to explain the global experience but not the history of gender equality in specific contexts at the regional or national level.

Booth, C. & Bennett, C. 2002, 'Gender Mainstreaming in the European Union', *European Journal of Women's Studies*, vol. 9, no. 4, pp. 430-46.

women and men in employment in the European Court of Justice (Hoskyns, 1996, cited in Rees, 2005). This was combined with an increasing demand from feminist movements and resulted in various EU directives (equal pay for men and women, 1975; equal treatment as regards employment and working conditions, 1976; equal treatment in social security, 1978) (Booth & Bennett, 2002). Various legal provisions were then developed regarding equal access to employment, vocational training, working conditions and, to a lesser extent, social protection. These legal provisions vary in scope from binding member states to implement national legislation to serving merely as a guiding policy. The equal treatment perspective is characterised by an individualised rights-based approach that relies on legal redress to promote equality once discrimination has already occurred. The implicit assumption is, therefore, that institutions are gender neutral and power relations become invisible. The incapacity of the liberal norm of 'equality' to deliver substantial socio-economic change in contemporary liberal democratic societies has come in for severe criticism at both the national and EU levels (e.g. Fredman 1997; Shaw, 2000). These criticisms led to a new approach to gender equality which recognised the structural disadvantage of women and therefore promoted a range of positive actions in order to improve the position of women in society.

The women's perspective thus inspires legislation and policy that focus on women who are presumed to be in need of particular treatment and specialist provision. This perspective recognises how past experience of discrimination and disadvantage has become institutionalised and therefore needs to be put right (Booth & Bennett, 2002). Rees (2005) terms this positive action phase 'tailoring', placing particular emphasis on group disadvantage, specific projects and measures. This was the dominant approach of the 1980s although

the recent emphasis on quotas and targets conceptually fits into this approach. In the 1980s, it was acknowledged at European level that there was a need to increase women's representation in the labour market. Thus, various initiatives were developed specifically to facilitate the incorporation of more women into training, employment and enterprise. For example, childcare and transport on the one hand, and confidence building and networks on the other, were all given impetus in order to facilitate women's participation in the labour market (Rees, 2005, p. 558). Quotas for women's formal representation in political parties, evaluation committees, scientific committees and other decision-making bodies have gained ground. Despite the fact that some authors classify this approach as gender mainstreaming (as it coincides with the dominant mainstreaming approach) it is conceptually different for a number of reasons. Quotas for women's representation are based on an attempt to redress the structural disadvantage faced by women in institutions and decision-making bodies. It is a positive action (that can be legally binding) developed to specifically enhance the position of women in decision-making bodies. There have been several critiques of the positive action approach, especially as to how the difference between men and women is conceptualised as problematic. Women are seen to be in need of measures to put them on an equal footing with men but there is no recognition of the need to change the rules of the game. This recognition led to the currently dominant approach of gender mainstreaming.

The gender perspective promotes actions that will lead the organisation of society towards a fairer distribution of human responsibilities that can be delivered by means of new tools for gender-sensitive policy-making (Booth & Bennett, 2002). This approach has been dominant since the 1990s and termed by Rees (2005) as 'transforming' due to its emphasis on systems and structures that add to group

disadvantage. Its overall aim is to integrate gender equality into mainstream systems, structures, policies and institutions. Gender mainstreaming does not rely on law enforcement mechanisms but involves a long-term transformation of public policy (Stratigaki, 2005, p. 167). Gender mainstreaming, in fact, relies more heavily on so-called 'soft' (i.e. legally non-binding) policy instruments and voluntary cooperation (Mazey, 2002). The question remains as to whether this, in the long term, implies a watering-down of equality concepts enshrined in the existing equality directives. Criticism of gender mainstreaming examines how it becomes lost in implementation/practice: as it is 'all-embracing', no-one assumes responsibility, while women's offices have been dismantled. The conditions necessary for effective gender mainstreaming in terms of law and policy-making, and thus implementation, have not been clearly specified or understood (Beveridge et al., 2000).

Policy instruments

One important conceptual distinction concerns the different instruments with which policy on gender equity is implemented. The report of Rees et al. (2002) on *National Policies on Women in Science in Europe* draws a distinction between positive action measures and gender mainstreaming although, as we have confirmed in our analysis of the literature, this distinction is not clear cut; on the contrary, both types of measures are increasingly combined and seen to complement each other for different gender policy purposes.

There are different definitions of gender mainstreaming as well as considerable variation in practice (Walby, 2005), as this concept encapsulates some of the dilemmas in feminist theory and practice, and offers a new focus for debates on how to advance gender equality (Crompton, 2001; Rees, 2005).

Positive action comprises a wide range of interventions in Higher Education, public and private organisations and the labour market, in order to give women more opportunities to overcome gender inequalities. The implementation of positive action has to consider the target population, the goals to be reached and the tools to be deployed, (such as the funding required) and other policy instruments that must be specified in order to assess outputs and objectives.

The main positive action measures in science identified by Rees et al. (2002) are:

- Networks, i.e. the setting-up of or support for women's scientific networks and equal opportunities networks.
- Quotas and targets, i.e. specific procedures for appointing women where equally suitable candidates exist in order to achieve a better gender balance and facilitate women's advancement to top positions.
- Role models and mentoring, i.e. actions which demonstrate that it is possible to be a woman and a senior figure in science (role models) and schemes to link senior women scientists with junior colleagues for advice and support (mentoring).
- Earmarked chairs, research funds and prizes, i.e. earmarking resources for women scientists, either in terms of encouraging the participation of women, setting women's targets or devoting these resources only to women.

In addition to these measures, our reviewed literature also suggests:

- Women's universities and specific summer schools, i.e., exclusive education for women.

Gender mainstreaming is a long-term and strategic approach to fostering gender equality, designed to complement legal equal treatment and positive action measures. It

entails the systematic integration of gender equality into all systems and structures, policies, programmes, processes and projects, into ways of seeing and doing. In this way, gender mainstreaming is a transformative strategy which seeks change particularly in the spheres of culture and organisation. The most common gender mainstreaming approaches, as identified by Rees et al. (2002), are:

- Legislation, i.e. including equal opportunities issues in the legislation regulating higher education, and specifically regulations to ensure gender balance in public bodies, including scientific committees.
- Gender studies, i.e. gender-sensitive studies on science, addressing issues such as gender relations in scientific careers, gender impact assessment of institutional practices and gendering excellence.
- Modernising human resource management, i.e. measures aimed at avoiding nepotism, patronage and sexism in human resource management, such as measures for ensuring transparency in appointment and promotion procedures and for avoiding any potential gender bias in assessing merit and scientific excellence.
- Gender-proofing the pedagogy of science education, i.e. a thorough examination of pedagogy, its methods and instruments, in order to avoid potential gender biases.
- Work-life balance measures, i.e. policies promoting a good work-life balance throughout the life course for both women and men.

In addition to the previous approaches, from our review of the literature, mainstreaming includes further measures such as:

- Women's officers and women's representatives in research and higher education institutions.

- Gender observatories, i.e. specific university-based or public institutions that monitor the representation of women and act as consultants for implementing equity measures.
- Evaluation procedures for gender-proofing research and funding, specifically in the EU Framework Programmes, as well as criteria of excellence in scientific careers.

In the majority of countries and at various institutional levels, both perspectives (positive action and gender mainstreaming) overlap and have been adopted simultaneously.

Both strategies seem to mutually reinforce and foster the success of equity policies, but several authors emphasise the different role that positive action plays in the contextualisation of gender equity with respect to gender mainstreaming. Rees (2005, p. 560) claims that 'positive action projects can be the laboratory for the development of good practice to implement in the mainstream'. In this context, positive action would be a part of the main goal pursued by gender mainstreaming. From a different position, Stratigaki (2005) considers the introduction of gender mainstreaming as a complementary strategy, but one that does not replace previous gender-specific equality policies, for example equal treatment legislation and positive action. She also rejects the prevalence of gender mainstreaming as an alternative to positive action that aims to carry out specific policies on gender equity. Daly (2005, p. 441) offers another vision of the term, claiming that 'many of the initiatives implemented under the rubric of gender mainstreaming draw philosophically from a positive approach'. She notes how critiques draw attention to the technocratic approach of gender mainstreaming, underlining that it was developed by technocrats rather than being based on civil society's struggles for women's advancement (Daly, 2005; Rees, 2005). Nevertheless, gender mainstreaming involves

a critical position regarding the persistence of a patriarchal and 'malestream' society that should be overcome and goes beyond the 'tailoring' of positive measures (Rees, 2005).

Another interesting dimension of the debate considers to what extent mainstreaming policies overlap with the 'diversity' perspective as a means of advancing gender equity policies. Dolowitz (2008, pp. 89-90) presents both strategies as alternative positions adopted in the 1990s. While European Union institutions incorporated mainstreaming into community policies, in the United States diversity was promoted as a remedy against discrimination. Diversity policies appear as new management tools of private corporations (albeit also present in universities and other organisations) in order to recruit diverse candidates to enhance innovation and creativity. It is also adopted as a means to foster social responsibility, in order that organisations reflect the diverse society we live in. This approach integrates a liberal conception of the competitive enterprise while considering new candidates (for example women, but also the elderly, immigrants and other minorities) that have been traditionally excluded from the labour market.

Policy transfer

Among the implicit objectives of the meta-analysis is that of distilling new insights by comparing the different policy experiences available throughout the EU countries. The well-developed research field of comparative analysis of public policies provides an important starting point for carrying out this cross-national analysis. Based on a long tradition in political science, it allows for the identification of the most important dimensions for enriching the possible comparison between, and transfer of, policies.

Analytically, the literature distinguishes between policy 'transfer', 'convergence' and

'diffusion' studies (Knill, 2005). Although these differences – diffusion and transfer studies being concerned with process patterns and convergence studies with effects – are important in terms of research design and explanatory models, our primary interest lies in more 'practical' questions concerning the actors of policy transfer or its facilitating and constraining factors. Dolowitz and Marsh (1996, 2000) build upon the earlier approaches of Bennett (1991a, 1991b) and Rose (1991, 1993) to provide a contemporary analytical framework for analysing policy transfer.

Dolowitz and Marsh (2000) identify nine main categories of political actors engaged in policy transfer: elected officials, political parties, bureaucrats/civil servants, pressure groups, policy entrepreneurs and experts, transnational corporations, think tanks, supra-national and non-governmental institutions. Apart from these actors, a further important distinction concerns the content of policy transfer. In responding to the question of 'what gets transferred', one can differentiate broadly between the content (motivation) of a certain policy and its concrete implementation. Thus, transfer concerns policy goals and content, policy instruments and administrative techniques, policy programmes (concrete implementation), institutions, ideologies, ideas and attitudes, and negative lessons.

Overall, the literature has identified several important factors that determine the 'success' of a certain policy transfer. Whereas in the past, excessive focus was given to the role of individual actors (politicians, bureaucrats, etc.), currently a more ecologically-oriented perspective is put forward, where individual agents operate under the constraints of past policies, existing socio-economic conditions, an ideological climate or the efficiency of the available bureaucratic and administrative infrastructure (see Dolowitz & Marsh, 1996, p. 353ff) Thus, policy transfer is usually a complex process situated on a continuum

between several voluntary and coercive factors. Although actors might be quite willing to implement a certain policy, a lack of existing resources, institutional barriers or an oversized and incompetent bureaucratic sector easily diminishes the policy goal throughout the many phases of its implementation. On the other hand, the best and most efficient government organisation might be in vain if a certain policy transfer founders against the ideological and cultural resistance of its collective target. Indeed, Hall (1993) establishes a certain hierarchy suggesting that change (and hence, successful policy transfer) is most difficult when it comes to ideas, given their deep embeddedness in dominant beliefs. Instruments, policy programmes or even administrative settings can be transferred more easily since they are not dependent upon deep cultural and ideological changes.

Two levels may be particularly pertinent when considering the possibilities of policy transfer in terms of equal opportunities in science within the EU countries. First, there are the national differences. Given the present situation of the EU member countries, it is evident that differences exist at the level of the available economic resources invested in R&D&i activities (see UNU-MERIT, 2008). However, it is not only the economic back-up that frames the chances of success of gender-equality policies, but also the existing organisation and infrastructure of the higher education and research system. At national levels, the available literature of the GSD demonstrates quite convincingly that a clear policy transfer in terms of goals and instruments towards the new Eastern member states has occurred, whereas the adoption of concrete policy programmes is still missing.

Second, differences (individual universities and other higher education institutions) at institutional level might be especially important for the successful transfer of

gender and science policies. Many concrete policy programmes and activities are associated with concrete institutions. It would be particularly interesting to flesh out the differences between these institutions in order to identify aspects of success or failure when implementing higher level policy goals of gender equity in science. Important aspects could involve the type of human resource management, the existence of a corporate culture, ties to business, and so on.

Policy evaluation

The evaluation of existing policies is an imminent task. This is often conceived as determining the effectiveness and impact of certain measures for gender equality. Since the key indicator of the success of a policy towards gender equity in science relates to the proportional participation of women in all areas of science and research, evaluation is easily misconceived as determining whether certain policy measures have been effective in increasing women's participation in science. However, as straightforward as this may sound, evaluation is a far more complex and multilayered undertaking.

There are many definitions of evaluation (see for the following Stufflebeam & Shinkfield, 2007, p. 8). A widely used standard definition by the Joint Committee on Standards for Educational Evaluation published in 1981/1991 reads as follows: 'evaluation is the systematic assessment of the worth or merit of an object'. This definition goes beyond one of the earliest and still most widely used definitions which conceives evaluation as determining whether objectives have been achieved. Although this second definition might be more intuitive, it is not sufficient because given objectives might be corrupt, dysfunctional, unimportant or fail to address the needs of the intended beneficiaries. Moreover, the earlier focus on outcomes

limits the evaluation by focusing too much on results while forgetting programme goals, structure, and process.

Evaluation is a wide-ranging field. The Joint Committee distinguishes broadly between personnel, programme and student evaluations. Although evaluation of students and researchers is a contested terrain and highly relevant in terms of gender, policy on equity in science requires programme evaluation approaches. Within programme evaluations, Daniel Stufflebeam has on various occasions charted the different approaches available (Stufflebeam & Webster, 1980; Stufflebeam & Madaus, 2002; see also Mark et al., 2006, p. 13). A total of 22 different approaches can be identified and classified in four large categories: (a) pseudo-evaluations, (b) questions-/methods-oriented, (c) improvement/accountability, (d) social agenda advocacy (Stufflebeam & Madaus, 2002, p. 36). This last approach is especially interesting for evaluations in the field of gender equity because it aims at comprehensive evaluations that pertain to the relativist school and stress the need for deliberation and democratic principles among all stakeholders involved in programmes and their evaluation.

The definition by the Joint Committee also clarifies from the start that all evaluation involves value judgements. These value judgements should be related to the worth and merit of a given programme. A programme has 'merit' if it performs well according to its purpose. It concerns the internal quality of a given programme. 'Worth', in contrast, assesses whether a given programme addresses a real need. It is therefore tied to a needs assessment. This definition has important political and epistemological consequences. As Bovens et al. (2006) write, public policy evaluation is the continuation of politics by other means. Scales of measurement, indicators of quality or definitions of success and failure are highly contested, value-laden social constructions.

Evaluations thus not only provide feedback on the 'effectiveness' of certain measures (their merit) but also imply an agreement on its worth, i.e. whether or not it address a real need. Since women are still underrepresented in science decision making structures, social-agenda/advocacy approaches provide an opportunity to collectively define and negotiate the desired worth and merit of policy measures. In general, the evaluation of policy involves three aspects (see also Wroblewski 2007, p. 17):

1. A normative aspect, especially apparent in an analysis of the goals to be achieved. Questions asked usually include: What is the target group (e.g. students, professors, selection committees and rectors, among others) to be addressed? What resources are required (and are they realistic given the goals set)? Do the objectives address a real problem and need? What is the goal (for example, to increase the proportion of women in science? to aim for more ephemeral objectives such as change in sensibility towards gender issues or professional culture)?
2. An analysis of the implementation process. Does the implementation address the goal set? How does implementation change over time? What factors support or hamper the implementation? Policy implementation under a post-positivist paradigm acknowledges that implementation is never a straightforward 1:1 process (see e.g. Winship 2006; Hajer & Wagenaar, 2003). The reception and implementation of policy depends on many contextual factors, personal relations, margins for interpretation, accommodation and resistance.
3. An analysis of its impact. Analysing the possible impact of policy poses a further major challenge. As the GSD literature shows, most evaluations concern the effects of certain measures at the level of

the individual scientist. The benefit in terms of new skills, motivation and self-esteem of certain measures such as career training is relatively easily captured by interviews and surveys among the participants. However, the 'structural' impact dimensions are much harder to evaluate. Qualitative changes at the level of perceptions and dispositions towards gender take place rather slowly; detecting cultural change requires a large and elaborate methodological apparatus. But even then, determining the effectiveness of a certain policy measure is a difficult task since it always forms part of a wider social reality. Research that attempts to isolate cause-effect relations that would venture to trace changes in the scientific environment to certain policy interventions is quite scarce, due, in part, to the additional difficulties of limiting the timeframe for scrutinising potential effects.

Given these challenges and dimensions inherent in evaluations, certain types of evaluations are more realistic and probable than others. When considering the entries in the GSD – apart from the few systematic evaluations carried out in general – it becomes apparent that the majority of approaches concentrate on the individual (satisfaction, benefit) level. Surveys and interviews before and after certain activities such as training seminars, summer schools, etc. are relatively easy to carry out and are thus frequent. Apart from being relatively 'simple' and direct they also have the advantage of being bound in space and time. Large-scale evaluations that not only focus on individual benefits but on structural change are much harder to come by. They are more costly, both methodologically and financially.

This can readily be seen in relation to the implementation of gender mainstreaming. To start with, there are a variety of definitions circulating which often present different ideas on how best to implement mainstreaming

(Walby, 2005; Stratigaki, 2005). As a consequence, the real effects are not clear and evaluation becomes difficult. Diversity between countries and between institutions within the same country is also a source of difficulty in terms of the design and evaluation of these policies (Crompton & Le Feuvre, 1996; Crompton, 2001). Given the diversity in national, regional and university contexts, the scarcity of comparative and benchmarking studies comes as no surprise.

The evaluation of policy on gender equality is thus confronted with several inherent and contextual difficulties. The clear need for the future is to overcome often isolated and local studies and to understand the interplay between several measures (career, structural reform, institutionalisation processes) and contextual factors (such as wider workforce participation and availability of child care facilities, to name just a few). Their coherence and consistency in relation to each other must be considered. Thus, the need for more comprehensive approaches also points to a shared set of quality standards for evaluation that would make different approaches comparable.

3.3.2 Policy research

In this section we present a critical review of the literature dealing with the evaluation of and comparison between policies on gender equity in science, following the conceptual dimensions presented above. Policy research is rather foregrounded in one of the following three thematic areas:

- Advancing science careers through career and skills training, stipends and scholarships, networking and mentoring, and measures for work-life balance.
- Science and management and reform, including the role of new legislative frameworks, institutional structures such

as equality officers, committees and observatories, quotas, or new steering instruments such as incentives and targets.

- Gender dimension in research and higher education, including gender proofing pedagogy and curricula, exclusive education, the institutionalisation of Gender Studies and gender assessment of research.

All these measures and policies refer to academia, and mostly the higher education (HE) system, as literature dealing with the evaluation of gender equity policies in non-academic settings is almost absent from the GSD.

In contrast to other reports issued by the European Commission, our analysis does not aim to provide an exhaustive overview of existing policies. Besides the macro-level of gender and science policy, it also incorporates concrete empirical research and evaluations of meso- and micro-level interventions, which allows for a more detailed assessment of the quality and potential impact of these gender policies and programmes.

Spanning a wide variety of different initiatives from the EU level down to single departmental measures, the resulting information on the potential impacts and effects of certain policy

Box 41. Findings from the meta-analysis of the literature dealing with policies towards gender equity in research

Measures for advancing women science careers

- Highly beneficial at the individual level but unclear impact on the structural level.
- Importance of disciplinary differences for successful policies.
- Level of institutional involvement is key.
- Need to rethink linear model of science career (re-entry schemes).

Science management and reform

- Agreement on central (informal) role of equality officers.
- Importance to politicize apparently neutral allocation formulas.
- Very patchy results on gendered impact of Higher Education reform.

Gender in research and Higher Education

- Modest reform in curriculum and pedagogy has minor effects.
- Single-sex measures are positively received but not systematically explored: cultural change in SET?
- Mapping and the effects of the institutionalization of gender studies remains to be drawn.

Castaño, C., Müller, J., González, A. & Palmén, R. 2010, *Policy towards gender equity in science and research. Meta-analysis of gender and science research – Topic report*. Downloaded on 16/11/2010, available at: http://www.genderandscience.org/doc/TR7_Policies.pdf

measures has become more fine-grained but also much more heterogeneous. One obvious difficulty concerns drawing meaningful comparisons between the huge variety of individual and idiosyncratic studies. The variety of the thematic issues covered, combined with the diversity of methodologies used and, more notably, the differences between the concrete objectives, target groups and contextual settings (disciplinary, institutional, national, etc.) put a common framework of analysis out of easy reach. In addition, there is no shared cross-national understanding of what comprises policy evaluations, nor is there a 'disciplinary' culture of gender and science policy that would allow the dispersed experiences and studies to be conceived as addressing 'the same' problem. In general, what remains are descriptive rather than theoretically informed, (nationally and thematically) isolated studies. To be precise, this is the case for those few countries that actively engage in research and evaluations and make the results public. Nevertheless, despite these limitations, some common themes and issues are apparent and are summarised in the box below and the following paragraphs.

Measures for advancing women's science careers

According to the review of the literature, one can generally distinguish between three main areas where large-scale programmes have been implemented over the last decade in Europe. First, career and professional development programmes that involve all sorts of coaching and training activities that target the personal skill level of women in academia. Second, a bundle of measures offer stipends and position scholarships specifically geared to women in order to reach the next qualification level, either PhD or Habilitation for full professorships. And third, among the better-researched topics are women's support

networks, especially mentoring initiatives. While stipends and scholarships operate at a more structural level, both skills training and support networks foster women's careers at the individual level.

The analysis substantiated that career development and training seminars, mentoring or qualification stipends are highly beneficial for the individual scientist. Their impact on the structural level, however, remains unclear. The available literature leaves no doubt as to the positive effect of career training or mentoring programmes, for example. Even though these positive actions might potentially be stigmatised as 'women only' activities, the participating female scientists mostly reported very positive experiences with these types of support measures. However, what is clearly lacking is a more systematic discussion on how individual benefit and structural change might be tied together. Although there exists anecdotal evidence that these individual support measures trigger processes of sensitisation at the institutional level towards gender issues, there is no systematic approach, either theoretically or in the form of empirical research, which addresses how personal benefit and structural change might be interwoven. In general terms, these individual benefits have been repeatedly contrasted with concerns of 'making women adjust' to the male-dominated scientific culture. Career development for women scientists needs to be combined with changing science culture on the whole and should not be modelled on male-shaped job and life patterns. Isolated measures exclusively directed towards women are not effective enough. Another limitation is the fact that career advancement measures cannot be considered a remedy for the general lack of positions.

The literature on this topic also testifies to the importance of disciplinary differences: policies that are tailor-made for specific disciplines prove more effective than generic measures.

Considering the sub-topic of career training apart from stipends and mentoring schemes, it is apparent that the impact of equality measures in these areas depends on the historically developed specific culture and disciplinary requirements in place. This was consistently reported in EU collaborative projects but also in national projects that undertook comparative research on the differential impact of certain measures across the 'hard' and 'soft' sciences. Policy measures will need to take into account these disciplinary-specific aspects in order to be successful.

It is also clear that top-level involvement and institutional commitment to equality policies is a crucial factor for success. The comparison between stipends and direct positions is exemplary in this case. Both measures support women in their science career, although fixed positions have been described as more successful in terms of integrating scientists into existing networks and departments than merely providing economic resources. It is important not only that specific support measures exist, but also how they are implemented – where in the institutional hierarchy they are located, which level of the university administration is involved, what commitments are required by whom. The discussion barely focuses on these broader and more crucial aspects for advancing women's scientific careers beyond the individual scientist. Given that scientists traditionally enjoy a high degree of autonomy and independence, the way gender policy can penetrate work and organisational habits is key to making a real difference. This is especially apparent in terms of stipends vs. fixed PhD positions for women, where the latter was found to provide better integration of the PhD candidates into the institutional setting and scientific community. But it is also apparent in the way women were able to participate in the decision-making process in HE institutions and the governing body's commitment, or lack thereof, to gender issues. High-level implication

and commitment of the rector and/or dean were usually a prerequisite for making gender a real issue on the HE/research institutional agenda.

Within the science-career literature, the need to rethink the linear pipeline model and to take into account more dynamic and fragmented careers paths was manifest. Despite the fact that career breaks are penalised in science, there might be untapped possibilities and potentials for women entering science. The example of the lecturing stipends for Universities of Applied Science in Germany showed that it provided an effective way of encouraging women from the industry to re-enter HE. Relatively little is known about returning and re-entry schemes in relation to research and HE. Overall, there are few systematic and integrated policy approaches to women and science careers. Coordinated efforts that conceive and implement measures along the whole life-cycle (from schooling to university and eventually the transition to the private industry) while also involving a variety of stakeholders, such as different ministries and public and private research institutions, are clearly the exception (one notable exception is the Austrian fFORTE initiative, see box 42). Measures for advancing women's science careers are often limited in duration and scope, seriously hindering chances for synergies between many isolated efforts.

Another striking fact concerns the lack of evaluation reports on work-life balance measures. Despite the centrality of this issue for the scientists involved, there are few entries that directly scrutinise the (non-)impact of certain measures. One reason might be that work-life balance issues easily transcend the HE sector, as they involve regional and often national policies not easily contemplated in small-scale, project-centred research approaches. However, the necessity for a more complex research design can hardly

Box 42. fFORTE initiative

The Austrian fFORTE initiative *Women in Research and Technology* provides a singular case in terms of a coordinated and comprehensive approach to women and science. The overall goal of fFORTE consists of increasing the percentage of women in scientific and technological professions by making professional trajectories more attractive and by providing better access to these fields. fFORTE has integrated since its inception in 2003 a variety of individual measures broadly grouped into:

- structural measures such as integration of interdisciplinary research at universities or gender-impact assessments of national research programs
- qualification and career measures spanning secondary and higher education for improving access (*MUT, FIT, IMST*) and further qualification of women (*ditact_women's IT summer studies, Hertha-Firnberg positions, APART stipends, international fellowships*)
- training measures that include mentoring activities but also awareness raising of university and research managers (mentoring, coaching, *fFORTE_coaching*, gender training for teaching staff and human resources personnel)
- awareness measures such as prizes to make women's achievements in science more visible (*women science and technology day, FEMtech, biografiA, women environmental-technology award*)
- accompanying research programs in order to assess the impact of the devised initiatives (impact research, gender research program *GENDER IT*, evaluation of national science and funding processes)

fFORTE is singular not only in the way it conceives of a whole battery of gender policy measures starting from secondary schooling throughout higher education and the private research sector in an integrated way but also the way it is organized. The initiative is coordinated by an inter-ministerial group that involve members of the ministry for education, science and culture (bm:bwk), the ministry of economics and labour (BMWA), the ministry of traffic, innovation and technology (BMVIT), members of the research and technological development (RFT). According to Wroblewski et al. (2007, p. 235), this coordinated effort across several ministries enables change on the structural level due to the synergies made possible. The connection to the ministry of economics and labour (BMWA) for example guarantees a much stronger involvement of the private sector in these gender equity efforts than this is usually the case.

Wroblewski, A., Leitner, A., Gindl, M., Pellert, A., & Woitech, B. 2007, *Wirkungsanalyse frauenfördernder Maßnahmen des bm:bwk*, Kommissionsverlag Verlag Österreich, Vienna, pp.175ff.

explain the distinct lack of research on the impact of policy addressing work-life balance issues. Together with the fact that work-life balance is often wrongly used to explain the

underrepresentation of women in higher positions in science, the newly emerging dual-career couple scheme also makes this field an important area of future research.

Overall, the research carried out on the worth and merit of career measures is largely descriptive. When comparing research on mentoring carried out in the US and Europe, it is apparent that there is a certain lack of systematic discussion in Europe. There is little theme-driven research on scientific careers that carry out an in-depth analysis of some of its aspects; most reports are accompanying evaluative studies that reflect the logic of the specific programme or measure itself rather than certain thematic/theoretical questions. The reports are mostly descriptive and do not explain their theoretical assumptions and points of departure. Thus, research in this sense becomes rather repetitive in the problems it addresses and the solutions it proposes. This is not only true for mentoring, but also for the other aspects of women's promotion and science careers. This might be partly due to language issues; as noted by the present meta-analysis, comparison between countries is usually limited to specific EU collaborative projects –the rest of the national initiatives usually remain confined to their national languages. Hence, the need for more powerful theoretical work that would allow for more comparative research and the production of new knowledge.

Science management and reform

This section deals primarily with the literature on gendered aspects of institutional reform including legislative frameworks, the role of equality officers and equality committees, quotas, and new HE governance instruments, namely new steering instruments such as incentives and targets under NMP approaches.⁸

Without a doubt, the measures deployed for women's promotion in science and higher education have become more diverse and varied. Legislation and positive measures

such as the top-down creation of quotas now occasionally co-exist with newer governance instruments. Targets and incentive-based allocation of funds provide new means to reach 'old' goals: to increase the percentage of women in higher positions as well as across certain male-dominated disciplines, such as engineering and computing. The greater diversity in terms of policy instruments is now added to the pre-existing variety of policy contexts. The fact that HE now may differ not only between countries or regions but also within the same region (due to the autonomy institutions have gained in terms of 'how' certain targets are pursued) adds further to the complexity of policy transfer issues or comparative research on the 'effectiveness' of these new instruments.

The literature dealing with science management and reform leaves little doubt of the importance of equality officers at research and higher education institutions for advancing gender issues. Mostly barred from real decision-making power, these figures nevertheless manage to pinpoint concrete cases of discrimination and sensitise the entire scientific community to the importance of gender issues. Research has focused mainly on the micro-politics and tactics of equality representatives in their task of advancing women's issues at universities. In the context of recent HE reforms, their role often moves towards increasing expertise and professionalism concerning the gendered impact of new steering instruments.

The impact of new management instruments such as targets and incentives deployed at universities throughout Europe on gender-equality concerns is far from clear. Results are contradictory at best; the need to politicise new 'neutral' formula-based steering instruments has appeared more than once. It is important to note the country-specific uptake of NMP instruments in HE from a gender perspective. While the reviewed

⁸ See section 3.1.1 for a general overview of NMP approaches in academia.

literature in the UK paints a rather negative picture in which NPM reinforces the already existing male bias and disadvantages for women in HE, the German literature aims to co-opt NPM for gender equality concerns. The reasons for these different uptakes (which might be related to the different role of equality representatives in the respective countries) would be an interesting question in itself. We can point to different experiences –such as the Swiss case vs. certain German institutions like the Free University of Berlin– that provide first approximations of the potential and effects of NPM on gender equality in science and research.

In contrast, the findings concerning quotas and positive discrimination are quite consistent: they are not well received in academia by either women or men. However, it is also worth noting that the move from direct positive interventions towards an output-oriented steering approach seems to have stemmed many of the negative and pejorative arguments against positive actions, specifically ‘quotas’. Since women’s promotion has become part of greater quality concerns in the interest of all, they cannot be rejected as easily as before. However, as some of the reviewed contributions have made clear, while women’s promotion was formerly seen as an unjustified intrusion into the objectivity and meritocracy of science, now the danger lies in seeing it as interfering with the neutrality of economic and formal allocation procedures. Hence, the renewed importance of women’s representatives and equality officers, who continue to occupy key roles in order to politicise the apparently apolitical expert-based budgetary decisions. Apart from the danger of depoliticising formula-based allocation mechanisms and economic calculations, the introduction of managerial steering tends to make decisions less transparent and participatory. This might

turn out to be especially disadvantageous for women who are predominantly in the lower ranks of the HE and research hierarchy. In general, as Zimmermann (2003) maintains, the degree to which these new steering instruments and models are actually useful for furthering gender equality is among the most pressing and least satisfactorily answered problems in the current debate on gender equality policy in science and research.

Given the diversity not only among higher education institutions but also in the increasing variety of policy instruments, the lack of large-scale comparative studies is especially troubling. As already mentioned, evaluation studies usually focus on the impact of certain measures at the personal level. Considering the field of institutional reform, this concentration on individual benefits is especially striking. In view of the variety that exists within certain universities (between faculties and departments), there has been little research to date that addresses the impact of new steering instruments on women’s promotion and gender equality as a whole. Comparative studies between individual HE institutions or even between countries are equally rare.

Gender dimension in research and higher education

This section deals with gender as tied to the process of modernisation of higher education and research. This involves not only uncovering male power structures, but also improving the quality and diversity of knowledge. The insights into the close relationship between a more gender-sensitive approach to higher education and research and the resulting improvement in quality for all have made this an explicit policy target. As in the previous topics, the research documented on policy measures for pedagogical and curricular

reform is quite patchy. Although the literature discusses quite extensively the benefit of new teaching methods or the importance of gender proofing curricular content, relatively few concrete experiences have been documented so far.

Except for Wistedt (2001) and Verdonk et al. (2005, 2006) there is little systematic evidence regarding the obstacles and possibilities of combined pedagogical and curricular reform. It would be interesting to probe further into the relation between single-sex education, pedagogic reform and an interdisciplinary approach to knowledge. The women's university and single-sex degree courses in Germany are inspiring examples, but from the literature it is not clear to what extent real organisational and institutional change has been achieved (e.g. Knapp & Gransee, 2003; Sagebiel, 2005).

Girls-only summer camps and schools have been described as quite positive experiences. They provide possibilities of creating exclusive female environments unaffected by the typical derogatory judgements associated with other women-only measures such as quotas or single-sex courses. They provide valuable spaces in which to establish contacts and probe alternatives to the male-dominated science and technology fields. Despite the positive individual experiences of female participants, however, there is little evidence on their potential impact for attracting female students to technical careers or for transforming the dominant male SET culture. Isolated experiences are available on how a more diverse student population 'de-genders' the traditional male culture of computing (Lagesen, 2007; Blum et al., 2007) –how these experiences travel between countries, institutions or disciplines is, however, another matter. The section on single-sex education overlaps in this sense not only with the section on women-only

career training but also with its conclusions. These mono-educational experiences are highly beneficial for girls and women but there are no larger studies that analyse more carefully how it contributes to institutional change. In addition, the repeatedly stated difficulty in transforming existing well-respected and 'high status' engineering and science departments is somehow left unaddressed –except for the fact that the introduction of mono-educational settings usually provokes strong rejection that mirrors the pro/contra arguments on quotas. However, the crucial question of shifting power relations in the academy and how 'deep' cultural change could come about is not really considered.

The systematic research on single-sex education in women's colleges that exists in the US, especially in relation to potential benefits in academic performance, is not matched in the available literature in Europe. This might be partially due to the geographic restriction of single-sex HE experiences to Germany; however, given its potential benefits, not only in terms of academic performance but also in terms of, for example, networking, counter cultures and formulating alternative (i.e., more situated, ecological problem-oriented) ways of knowing, further research on single-sex education should be undertaken and its implementation in countries other than Germany should be promoted.

The map of the institutionalisation of gender and women's studies in Europe remains largely undrawn. There is evidence available from EU research projects in the form of case studies but there is no systematic research that describes in greater detail to what extent we really have moved towards a more holistic and problem-oriented production of knowledge (see Nowotny 1999).

Overall, the review of the literature showed that single-sex education measures have had

a positive impact. Summer camps and universities, workshops or girls-only work-camps are usually received positively by participating women. However, evidence of their structural impact and cultural change in science, engineering and technology fields is scarce. The same holds for the

institutionalisation of gender and women's studies. No systematic research was available. The results on the combination of curricular and pedagogical reform are also far from conclusive; however, it seems that gender concerns lead to a general improvement in the quality of teaching for all.

4

CONCLUSIONS AND RECOMMENDATIONS

The aim of this report was to provide a meta-analysis of the European literature dealing with the underlying causes of gender segregation in science. The overall picture is that there is no single-factor explanation for gender segregation in science. It has the same root causes as gender segregation in the labour market on the whole.

Research on gender segregation in science has developed in close relation to political debates and initiatives to foster women's advancement in science. While policy concern has gradually moved from women's recruitment to retention and career advancement, research has shifted from socialisation to organisational approaches, paying special attention to vertical segregation. The initial focus was on gendered socialization –how from an early age individuals internalise 'feminine' and 'masculine' roles that shape their educational and professional choices. The 1990s witnessed a gradual shift in research towards organisations and professions, their implicit norms and standards, institutional practices and power relations. Recent studies have tended to address the progressive differentiation of men's and women's careers through both supply-side and demand-side factors and have paid increasing attention to overcoming gender biases in knowledge production.

Gender segregation in education is widely acknowledged as one of the roots of gender segregation in science. In spite of desegregation trends over the last decades, study field choices remain largely gendered. The meta-analysis shows that some strands of the literature are still based on the assumption that the underachievement of girls compared to boys in maths is the main reason for gender imbalance in university studies. However, differences in maths achievement are narrowing or have disappeared and achievement in maths at

school is not a good predictor of choice of study field at university (girls with talent in maths make more diverse choices than equally talented boys). To account for gendered motivations and interests and to gain a better understanding of the educational choices of girls and boys, the main focus of explanatory factors needs to be changed from an analysis of maths performance to gendered socialisation and its interplay with structural and life-course factors. The degree of integration/differentiation in the educational system and the extent of gender equality in society are pointed out as relevant factors.

The review of the literature shows that family and career tensions play an important role in explaining the low rates of women embarking on a scientific career. These tensions are especially acute in the early stages of the academic career, from the first university degree to the first tenure-track position, a long period of career formation with intense productivity and mobility demands that coincides with women's childbearing years and social expectations about the right moment to establish a family. The family-or-science dilemma is not only gendered, but exacerbated by institutional constraints and implicit academic norms, values and expectations that take the traditional male life-course as the norm. The 'myth' of total availability in the scientific lifestyle penalises involved parents, but also women as potential mothers. Many young women end up believing that science is incompatible with family life and feeling that they have to leave academia if they wish to have a family. And indeed, family related mobility and time constraints may act as a filter in early selection procedures.

The literature also stresses that family and career tensions cannot explain vertical segregation in science. Research shows that the professional and family trajectories of those women who manage to remain in

science are more aligned than ever to that of men. Overall, the available empirical studies do not show any clear evidence that women without children have better career prospects than their other female colleagues or that they succeed in catching up with men in their careers. Marriage and children do not appear to have a significant influence on women's scientific productivity and academic performance. To explain gender differences in scientific careers it is necessary to investigate more complex mechanisms, such as discrimination and cumulative advantage and disadvantage. Gender discrimination is seen to operate at two distinct, although closely connected, levels. The first is the lack of informal support in career advancement that leads to discouragement. The second level refers to bias in formal assessment procedures that leads to unequal access to research funding or academic positions. The definition and assessment of scientific excellence (the recognition of merit) is not independent of gender relations in academia and society at large. Overall, research concurs that women's poorer networking resources is a powerful, albeit subtle, explanatory mechanism for understanding women's greater attrition and slower career progression compared to men's. It works through an accumulative logic of 'non occurrences' and slight exclusionary practices that progressively disadvantage women's careers and cause a sensation of isolation, difficulty in assuming the risks inherent to the scientific career and low professional self-esteem. Women's slight disadvantages from the early stages of the scientific career might turn into wide differences in career outcomes.

Academia is the dominant concern in the literature on gender and science, with only few studies dealing with industry and other non-academic R&D areas. The overall picture of gender inequality in industrial research, nevertheless, appears to be quite similar to that of academia. Subtle forms of gender

discrimination appear to be closely connected to the long hours culture and the lack of flexibility in balancing professional and private lives, shaping a work culture which lacks the atmosphere of inclusiveness. However, research also stresses that human resource management is more developed in industry than in academia and may play an important role in the promotion of an inclusive work culture, with better career support, more transparent recruitment and promotion procedures and a tight focus on recruiting talent and diversity management. Recent studies have shown an increase in the number of women leaving academia in order to take up careers in other science- and technology-related professions, which provide not only new career paths, but also more favourable working conditions.

In parallel the literature shows an emerging trend towards the erosion of hierarchy and individual competition in certain university departments and R&D firms, which may also favour women's career prospects. A recurrent theme is the drastic change that scientific practice is experiencing and the obsolescence of individualistic reward criteria as science becomes increasingly complex and collective. From this point of view, it is argued that scientists of both sexes (and science itself) would benefit from systems of recruitment, assessment and promotion that took this collective dimension more properly into account. This trend may be seen as consistent with a certain degendering of scientific institutions, driven by the fact that many young women and some young men nowadays appear to want a more balanced life and are not willing 'to pursue research as the main aim of life'.

However, these wishes collide with increasing competitive pressures in the academic institutions and R&D systems. Under current managerial approaches, the move towards greater transparency and accountability in

academic assessment procedures is coupled with increasing competition for research funding among institutions and individuals. Whilst the literature in Germany, Austria or Switzerland explores the ways in which these new approaches might serve to foster gender equality in academia, the UK literature, where managerialism has been in place longer, focuses rather on its gendered impact on the academic profession. The professionalisation of hiring and selection procedures on the basis of transparent and gender-blind performance criteria can be viewed as a challenge to traditional academic practices of patronage and nepotism. However, this trend is parallel to the intensification of work and individual competition and may exacerbate gender differences in career outcomes. Gender-blind performance criteria are not necessarily gender-neutral: bibliometric indicators reflect the bias in favour of the past and the bias in favour of position in the network of relations. Furthermore, the use of such criteria is currently associated with elitist strategies in the allocation of scientific resources, which work against women and minority groups.

The current approach to gender equality in science involves not only supporting women, but reforming scientific institutions and overcoming gender biases in knowledge production. Gender biases in research limit scientific creativity, excellence, and benefit to society. It also hinders women's advancement in science in as much as women are currently a majority among scientists acknowledging the relevance of sex and gender analysis. Gender theory has had enormous impact in the humanities and social sciences over the past thirty years and is increasingly being integrated into medicine and the life sciences, although it is less developed in engineering and technology. Current approaches focus on gender as a resource for enhancing scientific excellence in basic and applied research.

Research on the evaluation of policies on gender equality in science and research shows a weak impact on institutions and scientific cultures. Institutional constraints and implicit norms and values remain largely unchanged. The same holds true for the persistence of gender bias in research methods, techniques and epistemologies. Women's advancement in science is slow and cannot be taken for granted. Policy action is needed for raising gender awareness and removing institutional constraints and biases. Empirical research is required in order to provide a sound basis for policy making.

Recommendations

Research has developed steadily through the 1990s and 2000s. However a large bulk of the literature in some countries is still mainly concerned with women's choices, barriers and deficits and fails to address the societal and institutional factors that are at play. With the overall purpose of promoting gender equality in science by degendering careers and facilitating non-linear career paths the main priority of research should be to build more consistent links between analysis and policy making. Recommendations can be grouped into four main issues:

1. Better statistics
2. Broader scope of research
3. Mainstreaming sex and gender analysis
4. Focus on institutional change and evaluation of gender equality policies

1. *Better statistics*

R&D and Innovation surveys allow for a clear identification of researchers, but information on qualitative aspects of their employment is very limited.

The European Labour Force Survey (ELFS) occupation and education definitions are linked to the United Nations classifications. The survey offers rich information on personal and family variables. In most countries, however, data are only partially broken down by public and private sector. Moreover, the ELFS does not make it possible to distinguish clearly between professional and research activities. This is an important flaw, given that most research takes place in firms for which R&D is not the principal activity domain. Despite these drawbacks, the ELFS is a valuable source of data for the analysis of scientific and technological employment and, in particular, 'human resources in science and technology' (HRST).

European initiatives like the publication of *She Figures* on a tri-annual basis since 2003 must be applauded. It constitutes a unique attempt and opportunity to build a comparable European database in order to monitor the relative position of women in science. Collecting more systematic sex-disaggregated data on pay and research funding should be a priority. In particular, research funding requires proper monitoring and the lack of transparency in the allocation of research grants and awards is a major obstacle.

Major hindrances for research are the lack of sex-disaggregated data on personal and career developments (including demographic variables such as the number of children, marital status, etc.) and the lack of longitudinal data. The systematic collection of personal and career data is of utmost importance for monitoring progress towards both family and career balance and gender equality in scientific institutions. Overall, further research on family and career tensions is needed, for both men and women, and not only dealing with parenthood but also with other issues, such as care of the elderly. More consistent data are also required to address intersectionality, looking at how gender and

other social inequalities interplay, which is a rather neglected issue. At the same time, research suffers from a lack of panel data, which hinders the development of longitudinal research, the best way of analysing the pattern of cumulative advantages and disadvantages that shape gender differences in scientific careers. The same holds true for any analysis that aims to take the relationship and reciprocal influences of personal and professional lives seriously into account.

2. *Broader scope of research*

Overall, research on gender and science should be less descriptive and more theoretically embedded within the strand of literature that analyses divergent patterns of feminisation and change in highly-skilled professions.

Only a small percentage of PhD holders (5-20%) pursue an 'excellent' academic career that culminates in a full professorship or similar post and to an even lesser extent enter the restricted circle of the scientific elite. More research is needed to fully understand the complex mix of structural barriers, discrimination and cumulative disadvantages that account for women's underrepresentation in the highest scientific positions. Gatekeeping policies and practices in research funding should be studied, including the recruitment of gatekeepers, and the impact of gatekeeping positions on the gatekeepers' own careers and network building. This also includes well-grounded qualitative research on the gender dimension of the hidden power dynamics that govern access to the elite positions.

However, the underrepresentation of women among 'excellent' scientists also means that more women than men follow other scientific paths in universities, research institutes, industrial R&D, or other science and technology related professions. Yet research in this field

is limited and reinforces gender bias in the analysis of scientific careers. This does not only mean that more attention should be paid to scientists who leave academia, follow discontinued careers or work below potential. Research should also address the development of science-related professions in non-academic settings and its gender dimension, including technicians working as research staff and technology transfer professions.

Finally, research should take fully into account that gender does not mean women and that gender relations are changing. Further research on different femininities and masculinities is needed, particularly in addressing gendered study choices, career and family conflict and scientists' interactions in professional settings.

3. *Mainstreaming sex and gender analysis*

The EU's DG Research has already established the framework for mainstreaming sex and gender analysis into basic and applied research. Recommendations for future actions include:

- a) Developing internationally agreed upon methods of sex and gender analysis

Undertaking a systematic review of existing methods of sex and gender analysis for science and technology. Gender analysis can enhance excellence in science, knowledge, technology, and design by stimulating innovation, creativity and greater social applicability.

Compiling and extending these methods and concepts to all sciences, medicine, and engineering. Globally agreed upon and locally customized methods of sex and gender analysis must work across the modern sciences, ethnosciences, and indigenous knowledge systems. Such a set of methods or frameworks would allow researchers and engineers to analyse problems systematically and to better seek innovative solutions that take the

complexity of factors into account. When developing methods, it is important to:

- Draw methods from all regions.
- Draw methods from across disciplines.
- Analyse differences and similarities across and between women and men.
- Analyse-covariates that interact with sex and gender, such as age, ethnicity, cultural factors, etc.
- Analyse sex and gender in research subjects at all levels, for example in the life sciences from the single cell through animal models to human subjects and processes.
- Include users' perspectives, i.e., by means of user-driven participatory design methods.

Developing sex and gender analysis in research and design throughout the life cycle of the project from setting research priorities, to choosing a specific subject for research, to planning the research process, to collecting and analysing data, etc. It is not enough simply to 'add on' a sex and gender component late on in a given project's development. Research must consider sex and gender from the beginning.

Challenging how research priorities are set. Research priorities, goals, and outcomes must meet boys' and girls', men's and women's specific needs as analysed and defined by sex and gender analysis. Key questions include: do women and men from different socioeconomic backgrounds and cultures benefit from a particular project? How are priorities set in the context of limited resources?

Establishing multi-disciplinary research and design centres and networks to develop gender and sex analyses and methods.

Developing gender mainstreaming instruments, such as guidelines and checklists for practitioners.

b) Training current researchers and evaluators in gender methodology

The University of Michigan's STRIDE programme and the GenSET project offer good models for how to engage S&T research as active participants in gender reform. While STRIDE and GenSET focused on institutional reform, they might serve as models for conveying methods of sex and gender analysis to researchers.

c) Holding senior management accountable for developing evaluation standards that take into account the proper implementation of gender analysis in research.

There are several practical ways to encourage researchers to develop the required expertise in sex and gender analysis:

- Granting agencies can require that all applicants include gender methodology in research design. Research projects that do not mainstream gender should not be funded.
- Hiring and promotion committees can evaluate researchers and educators on their success in implementing gender analysis. Knowledge and use of methods of sex and gender analysis can be one factor taken into consideration by institutions in hiring and promotion decisions.
- Editors of peer-reviewed journals can require sophisticated use of sex and gender methodology when selecting papers for publication. A number of journals already do this, e.g. the *Journal of the American College of Cardiology* and the American Heart Association journals. *Nature* is considering adopting this policy.

d) Training the next generation in methods of sex and gender analysis

Sex and gender analysis should be taught throughout the curriculum, including basic

science, medicine, and engineering curricula, at the primary, secondary, and tertiary levels. It is important that research institutions support programmes on gender studies where experts develop new knowledge on gender, science, and technology. Yet at the same time, gender analysis must also be taught to future S&T researchers. By mainstreaming gender analysis throughout the curriculum, the boundary between 'gender studies' and 'science' disappears; gender issues are fully integrated into S&T studies. In this way, students in technical fields learn methods of sex and gender analysis continuously throughout their studies. Textbooks should be revised to integrate gender methods.

4. Focus on institutional change and evaluation of gender equality policies

'In spite of persistent efforts of data-gathering, research and reflection over the last two decades, increasing knowledge about gender segregation in science has not led to significant improvement'. This is a rather common view among policy-makers and scientists committed to gender equality in science. We have argued that we do not know that much whilst some things have indeed changed, although change has not been mainly driven by explicit institutional intent. Building more consistent links between analysis and policy making is, in our view, the main priority for research. This means focusing more consistently on institutional developments and the evaluation of gender equality policies.

Current trends in scientific production and technological development depict a new scenario with increasing links between universities, research institutes and private firms and substantial changes in the structure of scientific careers. The literature refers to significant institutional changes that may lend support to more inclusiveness in recruitment procedures and working cultures in scientific and research institutions, as documented for

certain university departments and R&D firms. However they may also exacerbate individual competition and gender inequality in spite of greater gender awareness in scientific institutions and society at large. Greater attention should be paid to current institutional changes and their impact on gender equality. This entails reinforcing more consistent analysis of institutional change, ranging from in-built monitoring of institutional practices (i.e. scientific evaluation of scientific evaluation) to the development of comparative research, since patterns of exclusion and inclusion vary across national contexts and scientific disciplines – what is effective in a certain context may not be in another. In the field of gender equality policies, implementation strategies are primarily absent and if present are based on unrealistic assumptions about organisations and their potential for change (Simon, 2005). Evaluation of gender equality policies should be substantially reinforced. This includes:

- a) The need for common quality standards for evaluation

What the reviewed literature clearly demonstrates is a need for a common language of evaluation of policies. Existing studies and reports provide material that remains isolated, since a common framework enabling comparison is lacking. Evaluations are often linked to the objectives and implementation logic of the project under question and seldom respond to general considerations from an evaluation point of view. An example of this difficulty could be the confusion between gender equality and the deconstruction of a male-dominated science model vs. the simple increase of women in science (higher ranks).

A common evaluation framework might be useful for addressing the related problem of detecting structural change. The majority of approaches concentrate on the individual

level (satisfaction, benefit). Surveys and interviews before and after certain activities such as training seminars, summer schools, and so on, are frequent. However, large-scale evaluations that focus not only on individual benefits but on structural change are much harder to come by. Thus, indicators that would make the detection of structural, sustainable changes possible would be welcome.

There remains a clear need for future research which includes comprehensive approaches that go beyond the frequently isolated and local studies which would enable us to understand the interplay between several factors and measures, i.e., the possibility of combining mentoring with certain scholarships, single-sex degrees, etc. This also points to the need to make explicit the normative component of many evaluation studies. As already argued, evaluation of policies can be understood as the continuation of politics by other means. Therefore, it is important to argue carefully what 'desired' ideal states serve as a measuring stick for evaluation. Although individual benefits are important and a crucial stepping-stone, broader concerns and long-term issues beyond the micro-level have to be taken into account.

Last but not least, there is a need for a meta-reflection on the impact and possible effects of evaluations. Critical voices have claimed that evaluations have become just another bureaucratic obligation that has little real impact. This makes it necessary to reflect further on the different evaluation approaches available and their potential benefit for advancing gender issues in science – apart from their obvious role as steering/ monitoring instruments for performance-related targets.

- b) Need for theory and interdisciplinarity

Closely connected to the first need of a shared evaluation framework is the need for more

theory building. Most studies are descriptive and lack explicit theoretical references. The empirical situation under study is seldom distilled and exploited in terms of theoretical concerns or theory building. This reinforces the isolated nature and lack of comparison between case studies across Europe.

The lack of theory building is evident along several lines. Compared to research in the US, on mentoring or single-sex education, for example, it is apparent that the research in these areas does not address overarching questions, but rather focuses descriptively on the concrete measures carried out. This makes it hard to put the insights emerging from the evaluation case studies into dialogue with other studies and research carried out in the rest of the OECD countries. Time and time again, disciplinary and institutional differences turn out to be important factors for the successful implementation of certain promotion measures. In order to confront the resulting explosion of empirical details, it is necessary to develop theoretical models that help to see not only the pieces of the puzzle but how they might fit together.

In addition, with regard to interdisciplinarity, few cross-inspirations are taking place. For example, even such closely-related fields as primary and secondary education, which have a long history of reform attempts (including many failures), are not referred to in order to provide a better understanding of the many-sided aspects necessary for institutional change. As pointed out, the discussion on 'quotas', for example, does little to flesh out the similarities and differences between positive measures in the science context and other public areas, such as political representation. Especially rare are those cases in which an existing evaluation study would refer to or even further explore problems known from other disciplinary fields, such as organisation studies.

Considering the transferability of policies of equal opportunities in science within the EU countries, a clear policy transfer in terms of goals and instruments has occurred towards the new Eastern member states, while the implementation process is still rudimentary. Not surprisingly, from the literature one can confirm the importance of national legislation and policy frameworks for gender equality in science. In addition and crosswise, we have to consider the differences between the disciplines as important influential factors concerning what does and what does not work. And further, the specific institutional set-up is important especially as science is undergoing restructuring and changing its governance and steering mechanisms.

c) Need for research on long-term effects

A further clear need is tied to the lack of long-term research. The problem of rather isolated studies is further aggravated by the fact that most studies on policy on gender equality in science are also restricted in time. Most evaluations happen just before, during and shortly after the actual activities are carried out without being able to consider their long-term impact. It would be especially important to see not only what works but also why certain measures did not achieve the desired results or might even be counter-productive. This might be the case for certain examples where the continued emphasis on gender issues has installed 'equality' on a discursive level but not on a practical one. Transforming practice has to confront not only the ignorance of gender issues but also a lack of discrimination between the rhetoric of gender equality and real, cultural change.

Concluding remarks

The meta-analysis of the literature on gender and science demonstrates two facts: First, the dimensions of the scarcity of women at all

levels of science are well established. A decade of data-gathering, reflection and comparative analysis has demonstrated the reality of horizontal and vertical segregation, the existence of pay gaps, stereotypes, and the biased nature of criteria of excellence. Second, the move towards gender equality is slow and cannot be taken for granted. Women are increasingly underrepresented the higher one climbs up the scientific ladder. The persistence of these disadvantages requires a more comprehensive approach in policies for gender equity in science in the EU, which will be briefly outlined in the following paragraphs of this final section.

A crucial insight concerns the fact that in order to progress towards a truly developed knowledge society, science policy targeting the allocation of financial and human resources based on criteria of transparent and fair scientific evaluation procedures will not be sufficient. Rather, in order to take advantage of the existing pool of researchers and innovation talent, a cultural change in terms of challenging traditional gender roles, specifically in terms of more gender-balanced decision making in research, will be required. The scarcity of women in positions of power and science decision making is not a problem that will be resolved over time (as soon as the number of women candidates increase). In fact, the number of women candidates is increasing, but the participation of women in research activities is not associated with more funding for research and innovation or more intense private research efforts. Employers continue to be reluctant to incorporate women. The key challenge is not to change women but, on the contrary, to change the culture of science and research. This change would concern not only the definition and assessment of excellence but also issues relating to work-life balance.

The strong emphasis placed on work-family balance policies is oriented towards attracting and retaining female talent. The concept of

gender diversity is also incorporated as a key element of good management of research and innovation policies. Diversity is required not only for economic reasons (improving efficiency by the optimisation of human resources, gender equity would contribute to competitiveness); diversity also improves the quality of science and research by increasing creativity and bringing science closer to society.

Enhancing scientific excellence also requires overcoming gender biases in knowledge production through the mainstreaming of sex and gender analysis into basic and applied research in the fields of life sciences and technology. This entails addressing sex and gender analysis as a resource to stimulate creativity in science and technology, and by doing so enhance the lives of both men and women. The global leader in this policy approach has been the European Union's DG Research, although further support is needed to promote its implementation in scientific institutions.

Overall, the EU perspective involves a 'shift from formal equality to equality of opportunity or equality in numbers, to gender balance and equity' (EC, 2008, p. 23). It also involves a different sequence of measures in order to achieve gender goals. At present, the main challenge is not to define new policies but to reinforce their effects through an in-depth evaluation of measures and transferability of good practices. It implies developing sound theoretical frameworks, appropriate methodological tools and shared evaluation standards.

In the end, the new EU perspective on gender and science comprises the idea that gender policy is not only made by regulation and legal changes but mostly by leadership and a commitment to changing structures and cultures.

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This report summarises the main conclusions of the study 'Meta-analysis of gender and science research', a project of the 7th RTD Framework Programme of the European Union. Its main objective was to carry out a comprehensive analysis of the last thirty years of European research on horizontal and vertical gender segregation in science with a view to steering policy-making and to defining future research priorities in this field. A major output of the study was the creation of the Gender and Science Database (GSD), a unique online resource containing 4,500 European academic publications scanning three decades. Further details can be found on the website of the project, which gives access to the GSD and all the reports produced throughout the study (www.genderandscience.org)

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