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Sommaire – Content

INTRODUCTION TO THE SPECIAL ISSUE GENDER AND SCIENCE: OLD CHALLENGES, NEW APPROACHES

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This special issue on gender and science, brings together 10 articles that present some of the results of the study 'Meta-analysis of gender and science research' and its final conference 'Beyond the leaky pipeline: Challenges for research on gender and science', held in Brussels in October 2010. The 'meta-analysis' study was a project of the 7th RTD Framework Programme of the European Union, coordinated by Maria Caprile at the CIREM Foundation. 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. 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 all 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 7th Framework Programme (Croatia, Iceland, Israel, Norway, Switzerland, and Turkey). 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.

This introductory article summarises the main conclusions of our research project and presents the 10 articles comprised in this special issue. In addition to our synthesis report (Caprile et al. 2011), further details about the study and the conference can be found on the website of the study, which gives access to the GSD, all the reports produced in the framework of the study and the proceedings of the final conference (www.genderandscience.org). It also acknowledges all the experts who contributed to this research project, as national experts, members of the coordination team, of the advisory groups, keynote speakers and participants at the conference. We wish to express our deepest gratitude to all of them.

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 (Anker 1998; OECD 1998; Rubery & Fagan 1993). The literature usually distinguishes between different types of segregation. According to Bettio and Verashchagina (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, and so on. In the literature, vertical segregation is sometimes referred to as the 'glass ceiling', which points to the existence of invisible obstacles that lead to the scarcity of women in power and decision–making positions (Laufer 2002). 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 (Maron & Meulders 2008).

There is no evidence of any spontaneous movement towards a reduction in gender employment 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 (Bettio & Verashchagina 2009). As these authors point out, this occurs in spite of significant changes in the last decades: impressive advances of women in education, the loss of importance of physical attributes for productivity, the enforcement of equality legislation, changes in family roles and the stance taken by feminism in defiance of traditional gender norms. Current research, taking into account these trends, 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 these factors is diminishing, especially among younger cohorts of women (Bettio & Verashchagina 2009). However, women remain more severely underrepresented among researchers than among other highly qualified professionals (Caprile et al. 2011).

In this context, the move towards gender equality in science cannot be taken for granted (Meulders et al. 2010a, 2010b). Most studies emphasise that gender differences in scientific careers are decreasing for recent cohorts, with women's and men's professional and family trajectories becoming more aligned than ever with each other (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. 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 attempting 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 (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 (Xie & Shauman 2003): 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. The gap between the ideal meritocratic norms of science and the unequal gender relations in practice is what Etzkowitz calls the 'Athena Paradox', after the Greek goddess of wisdom: "Paradoxically, discriminatory social practices are accompanied by norms of science that expect scientists and their work to be assessed according to universalistic criteria (Merton 1973). In a disjuncture between ideal and reality, theory has overridden practice and, all too often, served to invisibilise rather than expose harms" (Etzkowitz 2007, p. 1).

Our 'meta-analysis' study shows that research on gender segregation in science has developed in close relation to political debates and initiatives to foster women's advancement in science (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 our study. 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 deeply rooted ideas about science being a 'masculine' field. The views of parents, teachers and peers contributed to forming strongly defined 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 scientific jobs were organised also needed to be changed. Policy focus moved from entry and qualification issues to retention and attrition rates, and accordingly, from individuals to scientific organisations, cultures and practices. 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: increasing women's participation in science and engineering will not be successful without restructuring institutions and mainstreaming gender analysis into knowledge production (Schiebinger 2008b).

Our review of the literature reflects a similar shift in research, from socialisation to organisational issues, with some recent studies also paying attention to mainstreaming gender analysis into scientific research and technological development. 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 focused on women's biographies and subjective experiences, their ways of building a professional identity and solving conflicts in a male-dominated environment and how they manage 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) provided an early account of the main gaps in this strand of the literature: 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; 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.

Owing, among other factors, to feminism and women scientists' activism, 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, gender discrimination in academia was paid further attention as a result of two major 'scandals': the article by Wennerås and Wold (1997), which provided evidence of sexism and nepotism in the peer-review system in Sweden, and the

report by the Massachusetts Institute of Technology, which publicly admitted to having given lower pay and fewer resources to female scientists than to male scientists of equal seniority (MIT 1999). Research placed particular emphasis on overt and covert discrimination against women, attempting to unveil the hidden mechanisms of male domination in scientific institutions (Bagilhole & Goode 2001; Krais 2000). The EC-commissioned ETAN report (Osborn et al. 2000) made a plea to overcome patronage and the 'old boys' network' in European academic institutions and to implement greater transparency and fairness in recruitment and assessment procedures.

Recent studies address the progressive differentiation of men and women's scientific careers through both supply-side and demand-side factors. Gender segregation in science is explained by 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 factors (Bettio & Verashchagina 2009). In this context, the need to overcome the shortcomings of the 'leaky pipeline' approach in both research and policymaking emerge clearly (Langberg 2006; Xie & Shauman 2003). The metaphor of the leaky pipeline bears witness to the fact that women are more severely underrepresented the higher the rung they reach on 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, thus overlooking the many interruptions and re-entries that may occur along the way. 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. Against these shortcomings, the life course perspective places the main 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. This approach 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. Moreover, current research is also beginning to pay increased attention to cultural and institutional diversity within science itself, claiming that it is necessary to analyse more thoroughly the mechanisms that underpin the feminisation process in specific national and professional contexts (Le Feuvre 2009). Besides, some recent studies centre on non-academic careers (Etzkowitz et al. 2009; Meulders & Caprile 2003; Smith-Doerr 2004), a topic largely neglected by the literature on gender and science. Finally, a new wave of studies focuses on the epistemological and methodological basis for mainstreaming gender analysis in life sciences and engineering (Klinge 2008; Schiebinger 2008a).

GENDER SEGREGATION IN SCIENTIFIC CAREERS

Research on gender segregation in scientific careers 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. Overall, research focuses 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 de-segregation 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 achieve a more equal 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 on the male model (Meulders et al. 2010a; Sagebiel & Vázquez-Cupeiro 2010). Second, a large 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 and, therefore, pays 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 (Else-Quest et al. 2010; Epstein et al. 1998; Sapienza 2008) whilst 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, as talented girls in maths make more diverse choices than equally talented boys (Alaluf et al. 2003a, Xie & Shauman 2003). 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. First of all, 'choice' should be used with caution: people live purposeful lives, but socialisation actors —family, school, peers, the media— play a major role. Furthermore, recent studies show that, in terms of educational achievement and study field choices, gender differences are less pronounced in more gender-equal societies (Guiso et al. 2009) and in more integrated education systems (Van Langen et al. 2006). Age also matters: adolescence tends to exacerbate traditionally gendered choices and highly-differentiated and rigid education systems entail that study choices made during adolescence determine to a greater extent university and professional paths. As stated by Bennet et al. (2010), age and its relevance in attitude formation is implicit in many studies, and yet 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 and professions at large. In general, 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, along with the fact that gender stereotypes may change, but gender stereotyping tends to persist.

The early stage of the scientific career is a rather long period which 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. Research shows that in each of these transition points, more women than men give up, are expelled or are not successful (ESF 2009; NAS 2007; NSF 1994). Although the proportion of women among PhD students, PhD holders and post-doctoral researchers has grown more or less steadily in most countries and scientific disciplines, women's attrition remains particularly high in the transition from post-doctoral positions to independent (tenured) positions (Blickenstaff 2005; Martínez et al. 2007), the moment at which an academic career is considered to be established. 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. It is a deeply-rooted assumption that future career progression relies very much on performance in the early stage of the scientific career, 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 in terms of mobility and productivity with the formation of a family appears to be especially difficult and requires that women develop sophisticated coping strategies in order to manage all of their demands successfully. Indeed, 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. 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 have been historically developed by male professionals with stay-at-home wives (NAS 2007). The 'ideal' academic career is based on the expectation of unlimited commitment to science and deviations or delays are penalised. The 'myth' of total dedication and availability in the scientific lifestyle penalises involved parents, but also women in general as potential mothers (Beaufaÿs & Krais 2005). Although the family-or-science dilemma is a general trend, the literature highlights that the extent of conflict may be more or less serious depending on institutional constraints and academic cultures, which show a great variety across national contexts and scientific fields. As Le Feuvre (2009) stresses, the scientists' family status presents striking cross-national differences: in Germany, the typical male professor is a family man with two or more children, whilst half of the female professors are childless; in contrast, the percentage of childless professors in France is similar for both sexes (around 13%), as is the percentage of professors with two or more children (64% of male professors, 69% of women professors).

Family-related mobility and time constraints may act as a filter in early selection procedures (Ledin et al. 2007, Manson & Gulden 2004), but family and career tensions cannot explain vertical segregation in science. As Palomba and Mennitti

(2001) highlight, the family-career dilemma is paradoxical: female scientists are more often unmarried and childless than their male colleagues and than women in general, but there is no conclusive research about the impact of maintaining the 'dual role' on women's dedication to science and scientific production. Put in other words, supply-side explanations such as motherhood or lower productivity cannot explain differential career outcomes for men and women in academia. Research shows that the professional trajectories of women who manage to remain in science are more aligned than ever to those of men, in terms of age, duration and career planning (Alaluf et al. 2003b; Lind 2006; NAS 2007). Overall, the available empirical studies do not provide any clear evidence that women without children have better career prospects than their 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 (Carabelli et al. 1999; Fox & Faver 1985; Kyvic 1990; Luukkonen-Gronow & Stolte-Heiskanen 1983; Zuckerman & Cole 1987). As Fox (2005) states, this counter-intuitive finding should be interpreted bearing in mind 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. Xie and Shauman (2003) show 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, such 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) two decades ago, "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".

In order to examine this, research has to go beyond the universalistic criteria and strict meritocratic 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. As Addis and Brouns (2004) stress, the 'making' of scientific excellence is not independent of gender relations in academia and society at large. When the academic ladder is conceived as a hierarchy of power, recognition and income, gender segregation is not only seen as the result of gendered time and mobility constraints: other forms of gender discrimination, usually hidden beneath the veil of the meritocratic ethos, do

emerge. 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 Krais (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, and Ural (2001) in Turkey. 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 – which may result in sexual harassment as documented by Bagilhole & Woodward (1995), Carstensen (2005) or Mankkinen (1995). As Husu (2005) underlines, 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 may be 'forgotten' when there is a place as a keynote speaker at a conference. What really happens may be that 'nothing happens' or that something that should take place does not happen: not being seen, heard, read, cited, invited, encouraged. As they are non-occurrences, this kind of discrimination is not easily identified or challengeable. The second level refers to bias in formal assessment procedures that leads to unequal 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 (Steinpreis et al. 1999; Foschi 2000), namely 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 (García de León et al. 2005; Menniti & Cappellaro 2000; Sabatier et al. 2006, Zimmermann 2000). 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 covert 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 disadvantages from the early stages of the scientific career might turn into wide differences in career outcomes (Rositter 1993; Valian 1999).

Academia is the dominant concern in the literature on gender and science, while very few studies deal with the industry and other non-academic R&D areas. The European Commission has played a major role in placing this issue on the political agenda through the support of comparative research (EC 2006; EC, 2009; Godfroy-Genin 2009; Meulders & Caprile 2003; Rübsamen-Waigmann et al. 2003; Valenduc et al. 2004). 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. Overall, gender inequality in industrial research appears to be quite similar to that of academia. However, specific trends related to work culture, career path, work organisation and human resource management are also relevant. In spite of

increasing interactions between universities, research institutes and R&D companies, academic and industrial research cultures continue to differ greatly and careers are segregated. In most European countries, statistical evidence suggests that the mobility of researchers between academia and industry mainly goes one way: scientists trained at university are likely to find a research position in industry, but returning from industry to academia is very rare, among other reasons, because the rigidity of academic institutions leaves little room for deviations in the academic career (ESF 2009). In industry there is nothing like the rigid norms and expectations that prevail in academia. Work cultures and systems of recruitment and promotion vary a great deal, and not only according to national contexts and research fields: they are also organisation-specific and even lab- or team-specific. However, non-academic careers appear to be as demanding as academic ones in terms of dedication and availability, and career progression in industrial research also relies heavily on performance in the early stages, which is likely to be the period of forming a family and having children. 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. In general terms, 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 and innovation activities, as well as other tasks and, eventually, management responsibilities. Research reflects 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) whilst others contend that it entails not only giving up research, but also losing a 'technical identity' that women have usually forged with considerable effort in a male-dominated field (Faulkner 2007). Finally, some studies stress that human resource management differs substantively in industry and academia. 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, funding institutions and students. The tradition of academic autonomy has meant that the human resource function of universities is rather underdeveloped, including support to underrepresented groups (Finch 2003; Ledwith 2000). Human resource management in industry may play a more important role in the promotion of an inclusive work culture, with stronger career support, greater transparency in recruitment and promotion procedures and a prime focus on recruiting talent and diversity management (Godfroy-Genin 2009; Smith 2008).

GENDER, INSTITUTIONS AND KNOWLEDGE

Recent developments in the field of gender and science research also show that closer attention is paid to the gender dimension of current institutional changes, the gender dimension of knowledge production and the evaluation of policies towards gender equality in science.

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 lead not only to new career paths, but also to more favourable working conditions (Etzkowitz et al. 2009; Ranga et al. 2008). Parallelly, the literature shows an

emerging trend towards the erosion of the hierarchy and individual competition in certain university departments and R&D firms, which may also favour women's career prospects. 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). Hasse and Trentemøller (2008) also conclude that there is a considerable degree of variation between university 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. 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 (Cheveigné 2009). 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 give fuller consideration to this collective dimension. This trend may be seen as consistent with a certain de-gendering 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' (Ajello et al. 2008).

However, these wishes collide with increasing competitive pressures in the academic institutions and R&D systems. 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 into 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 were first developed in the 1980s in UK universities, coupled with substantial cuts in public funding, a growth in student numbers and increasing 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, following 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 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 practice for longer, tends to focus on its gendered impact on the academic

profession. In particular, research in the UK (Knights & Richards 2003; Thomas & Davies 2002) highlights the double-edged nature of the trend towards external assessment: 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 intensification of work. As Addis (2010) points out, 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. 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 undergone significant changes (Blagojevic et al. 2003; Sretenova 2010).

Current approaches to gender equality in science involve not only supporting women and reforming scientific institutions, but also mainstreaming gender in knowledge production (Schiebinger 2008b). Western science —its methods, techniques, and epistemologies— is commonly celebrated for producing objective and universal knowledge which transcend cultural restraints. However, with respect to gender, race, and much else, science is not value-neutral. Research has documented how gender inequalities, built into society and research institutions, have influenced scientific knowledge and technology. Gender bias in research thwarts scientific creativity, excellence, and benefit to society. It also hinders women's advancement in science inasmuch as women are currently a majority among scientists acknowledging the relevance of sex and gender analysis. As stated by Schiebinger and Klinge (2010), rather than focusing on gender bias in scientific knowledge, current research approaches employ gender analysis as a resource to enhance scientific excellence. Gender theory has had an enormous impact on the humanities and social sciences over the past thirty years and is increasingly being integrated into medicine and the life sciences. Translating these often complex insights into readily usable methods for scientists and engineers is now emerging as the main priority for research. The genSET Consensus Report (genSET 2010) and the 2010 United Nations Expert Group on Gender, Science and Technology (UN 2010) recommend the development of internationally agreed upon methods for mainstreaming sex and gender analysis into basic and applied research. Projects to develop such methods are currently underway in Canada, the United States and Europe: the project What's Sex and Gender Got to Do With It? Integrating Sex and Gender into Health Research was launched by the Canadian Institute of Gender and Health; in 2009, the Clayman Institute for Gender Research at Stanford University initiated the Gendered Innovations in Science, Medicine, and Engineering Project; as of 2011, this project will expand through the collaboration with the European Union Unit for Scientific Culture and Gender Issues.

Research on the evaluation of gender equality policies in science is relatively scarce: these policies have become an important issue in all EU member states (Ruest-

Archambault 2008), but most evaluation and accompanying research is found in three countries (Germany, Austria and Switzerland) (Castaño et al. 2010). The variety of policy measures and the persistence of unacceptably high levels of inequalities (linked to pay, funding, career possibilities, and so on) across most EU countries make it imperative to examine the effectiveness and impact of these policies. Policy research is foregrounded in three thematic areas: 1) Advancing women's science careers through career and skills training, stipends and scholarships, networking and mentoring, and measures for work-life balance; 2) Science management and reform, including the implementation of new legislative frameworks, institutional structures such as equality officers, committees and observatories, quotas, or new steering instruments such as incentives and targets; 3) Gender dimension in research and higher education, including gender-proofing pedagogy and curricula, single-sex education, the institutionalisation of gender studies and gender assessment of research. In general terms, the research landscape is rather fragmented and little research has been carried out on either the long-term effects of certain policy measures, or on the interplay between several factors such as attraction measures, mono-education, mentoring, stipends, new governance instruments, and so forth. Overall, research shows a weak impact of gender equality policies on scientific institutions and scientific cultures. Measures for advancing women's science careers may be 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. However, the literature dealing with science management and reform leaves little doubt on the importance of Equality Officers at research institutions and universities for advancing gender issues (Bachmann et al. 2004; Barben et al. 2006; Roloff 2007; Roloff et al. 2007; Wroblenski et al. 2007).

SOME CONCLUDING REMARKS

Overall, our study shows that while policy action is needed for raising gender awareness and removing institutional constraints and biases, sustained efforts on data gathering and research have to be geared towards providing effective support to policy making and fostering the commitment to lead change in research institutions and knowledge production.

The study identifies the most under-researched themes as regards gender and science: 1) The topic of non-normative scientific careers is largely neglected. In general, studies centre 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 'tempos'. Industrial research and other science and technology-related professions remain under-researched; 2) 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 the 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; 3) Research on pay in scientific professions is scarce. It is a rather new topic of

study, for three reasons: first, due to the 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; 4) Research addressing the evaluation of gender equality policies in science 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; 5) Research tends to be descriptive and comparative research (across countries, scientific fields and institutional sectors) is scarce. Moreover, only rarely do studies adopt a longitudinal, life course perspective, which would potentially be useful to improve the understanding of the gendered patterns of cumulative advantages and disadvantages in scientific careers.

Our recommendations for research can be grouped into four main issues. First, we need better sex-disaggregated statistics, namely data on pay and research funding; on personal and career developments (including demographic variables such as the number of children and marital status) and, last but not least, we need longitudinal data. Second, the scope of research should be broadened. Research on gender and scientific careers 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. Research gaps should be addressed, namely pay and funding, assessment of scientific excellence and non-normative careers. Besides, 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. Third, more institutional efforts are essential in order to address the gender dimension of knowledge production. This means developing internationally agreed upon methods of sex and gender analysis, but also other measures such as training students, current researchers and evaluators in gender methodology and holding senior management accountable for developing evaluation standards that take it into account. Finally, research should focus more consistently on the gender dimension of current institutional developments. Current trends in scientific production and technological development depict a new scenario with increasing links between universities, research institutes and private firms as well as substantial changes in the structure of scientific careers. These developments may lend support to more inclusiveness in recruitment procedures and working cultures in scientific institutions, but they may also exacerbate individual competition and gender inequality in spite of greater gender awareness in science and society at large. Therefore, greater attention should be paid to current institutional changes and their impact on gender equality. This entails reinforcing more consistent analyses 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 and what is effective in a certain context may not be in another. Besides, evaluation of gender equality policies should be substantially reinforced. This includes comparative research on long-terms effects and more consistent efforts to orient empirical research towards interdisciplinary

theory building, with the development of sound theoretical frameworks and shared evaluation standards.

With this special issue we intend to address some of these priorities for research. The first set of articles deals with the overall debate and recent developments in the field of gender and science research. Henry Etzkowitz and Marina Ranga open this issue with a discussion on the gender dynamics in science and technology through an analysis of the 'vanish box' phenomenon that describes the migration of many female scientists from academia to new occupations emerging at the intersection between science and business, such as technology transfer. Cinnamon Bennet presents a review of the UK literature on gender and scientific careers with the aim of consolidating understanding and suggesting which of the contemporary policies, practices and concepts may offer the most promising way of moving beyond a view of the scientific career as a single, narrowing and prescribed trajectory. Nikolina Sretenova provides insight into the situation of men and women in science in the European Eastern countries as well as the most relevant research developments and policy debates in the field of gender and science. Finally, Anne-Sophie Godfroy questions some of the more usual assumptions explaining gender inequality in science in order to move towards a new set of more complex research questions and as such deepen the existing knowledge in this field.

The second set of articles presents the results of recent empirical research on gender inequality in scientific careers. Ruth Emerek and Britt Østergaard Larsen carried out a longitudinal analysis at Aalborg University which shows that the 'pipeline' leaks more women than men at the very first steps of the career ladder. Síle O'Dorchai provides an analysis of the gender pay gap within highly skilled professions, highlighting the extent of cross-country differences and the pressing need for more interpretative research in this field. Wendy Faulkner draws on ethnographic research in order to build the concept of 'gender (in)authenticity' and to reflect on the apparent congruence or non-congruence of gender and engineering identities for men and women engineers respectively, in terms of the normative pressures of 'the way things are'.

The final set of articles deals with the evaluation of gender equality policies in science. Jörg Müller, Cecilia Castaño, Ana González and Rachel Palmen present a review of the literature in this field and emphasise three key challenges: first, the integration of gender policy assessment with theories of social change; second, the gendering of innovation policy; and third, re-addressing the question of power and political struggle in relation to policy. Angela Wroblewski and Andrea Leitner focus on the role played by evaluation in the development of the policy mix to promote women and gender equality in science in Austria. Juliet Webster presents the results of an evaluation of the UK Resource Centre for Women in Science, Engineering and Technology, which deals with the possibilities and difficulties inherent in promoting women's advance in science over the longer term.

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