Horizontal and vertical segregation

Meta-analysis of gender and science research – Topic report

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The purpose of the study 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 study produced five country-group reports, seven topic reports and the final synthesis report:

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 Gonzalez & Rachel Palmen
Synthesis report - Authors	
Maria Caprile (coord.), Elisabetta Addis, Cecilia Castaño, Ineke Klinge, Marina Larios, Danièle Meulders, Jörg Müller, Síle O'Dorchai, Mária Palasik, Robert Plasman, Seppo Roivas, Felizitas Sagebiel, Londa Schiebinger, Núria Vallès, Susana Vázquez-Cupeiro	

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

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Introduction

Although men still outnumber women in science and research, women seem to be catching up as the proportion of female scientists and engineers or the share of women graduating at the PhD level in sciences are growing at a faster pace than men's. However, gender segregation across economic sectors and fields of science persists as does vertical segregation resulting in an unequal distribution of women and men across the different stages of a typical academic career.

It thus seems that even though there are many positive signs of change there is no natural or automatic move towards gender equality (and if there is it would take far too long to achieve). More efforts are needed to increase women's participation in the decision-making processes that shapes the entire scientific landscape.

The objective of this report is to present and analyse those studies in the Gender and Science database that deal with horizontal and vertical segregation in science and research.

The first part of this report focuses on the concepts of vertical and horizontal segregation. First, different definitions of segregation that were encountered in the literature are presented. Then, explanatory theories of segregation are developed as well as the methodology that is commonly used to quantify segregation. Segregation indicators are then presented followed by their comparison over European countries. Finally, this section is rounded off by an analysis of the evolution of segregation in Europe over recent years.

In the second part, we focus more specifically on gender segregation in the field of science and research. This part is mainly descriptive and is based on the available harmonized European data from She Figures 2003 (EC, 2004) and She Figures 2009, (EC 2009b). An attempt to draw the evolution over time and to compare the particular situation of researchers with the general degree of segregation in the total workforce is made.

The third part of the report is devoted to the description and analysis of gender segregation in the Gender and Science database. We first provide a statistical synthesis of the publications that deal with the topic of segregation in the Gender and Science Database. This part is followed by a presentation of the main research questions and methodology addressed by these publications on segregation. Finally, the results of the most relevant studies are presented.

The last part summarises the gaps that continue to exist both at the level of data and research and proposes several recommendations for further analyses.

1. Concepts and methodology

This section is divided into four parts. The first part offers a presentation of definitions of segregation and of its two main components; vertical and horizontal segregation. The second part presents a synthesis of the main theories explaining gender segregation in the labour market. One can distinguish three main theoretical currents: the neoclassical theories, the institutional theories, and the radical and gender theories. The third part presents the most common measures of gender segregation and proposes a list of existing indicators that allows one to evaluate the level of gender segregation in the labour market. Many indicators exist for measuring horizontal segregation while the methodology used to measure vertical segregation is less developed. Finally, the last part of this report provides an overview of the overall situation in Europe. It presents cross-country comparisons based on the two most common indicators for gender segregation in the labour market: the dissimilarity and the standardized indexes. The evolution over time is also described in this part.

1.1. General definition

Gender segregation refers to the tendency of women and men to work in different sectors and occupations. The situation in the labour market is that one gender dominates a given professional category (De Meyer et al., 1999).

Two types of segregation can be distinguished:

- Horizontal segregation is understood as under (over) representation of a certain group in occupations or sectors not ordered by any criterion (Bettio and Verashchagina, 2009). Horizontal segregation refers to the concentration of women and men in professions or sectors of economic activity.

  Horizontal segregation is a constant in the labour market in all OECD countries (Rubery and Fagan, 1993; Anker, 1998; OECD, 1998). Jonung (1998) anticipates a maintaining or even an accentuation of the professional segmentation. Effectively, the concentration of women in some sectors tends to grow over time (Franco, 2007). According to Anker (1998) horizontal segregation is a nearly immutable and universal characteristic of contemporary socio-economic systems. It also explains a part of the gender pay gap (Blau and Ferber, 1987).

- Vertical segregation refers to the under (over) representation of a clearly identifiable group of workers in occupations or sectors at the top of an ordering based on 'desirable' attributes – income, prestige, job stability etc, independent of the sector of activity. Under-representation at the top of occupation-specific ladders was subsumed under the heading of 'vertical segregation', whereas it is now more commonly termed 'hierarchical segregation'" (Bettio and Verashchagina, 2009, p. 32).

  In the literature, vertical segregation is referred to by the "glass ceiling" which points towards the existence of visible or invisible obstacles that lead to a scarcity of women in power and decision-making positions in public organizations, enterprises but also in associations and trade unions (Laufer, 2002). This phenomenon of barriers that prevent the ascension of women is complemented by the concept of "sticky floor". This concept describes the forces that tend to maintain women at the lowest levels in the organisational pyramid (Maron and Meulders, 2008).

1.2. Explanatory theories

Several theories attempt to explain the different situation of men and women in the labour market. In the following section, the explanatory factors are divided into three groups, the neo-classical theories based on the determinants of labour supply and demand, the institutional theories based on labour market segmentation and the role of institutions, and finally, the radical and gender theories based on the hypothesis that certain type of workers are in demand in the labour market whilst others are excluded.

1.2.1. Neoclassical theories

Neoclassical theories are based on the determinants of labour supply and demand.

1.2.1.1. Human capital theory

Human capital theory is based on the idea that decisions are made by female and male students, workers and employers and on the hypothesis that each individual accumulates a stock of human capital according to his investment in education and formation. For example, women who anticipate a career interruption due to maternity would invest less in education and formation (Mincer and Polacheck, 1974). They therefore accumulate less human capital than men which could prevent them from having access to occupations high up the professional hierarchy. Human capital theory is in this sense is no longer a powerful explanation given that women have caught up with men and even surpassed them in terms of educational attainments.

This theory has been transposed to the problem of segregation by Polachek (1981). Women and men are considered as rational agents using their capital differently according to their position: individuals will search for the best job according to their personal characteristics (such as education, experience, etc), their constraints (such as caring for children) and their preferences (such as flexibility of work time, favourable work conditions, etc). According to this theory, individuals maximise their income by maximising their investment in human capital in order to increase their productivity and wage perspectives whilst at the same time minimizing their costs.

Men tend to be oriented towards occupations and sectors where the level of productivity and responsibilities is high and invest more in their professional career. Women on the contrary tend to hold occupations compatible with their family life. The consequence is that women are better represented in occupations and sectors that require less investment in human capital, less productivity, that offer more part time employment possibilities and where the penalty linked to a career break is smaller. According to the OECD (2002), the hypothesis that women are oriented towards jobs associated with fewer promotion possibilities explains the lower degree of mobility in women's careers.

These factors determining women's and men's professional orientation are taken into consideration by employers when recruiting their employees. Given these factors, employers are more likely to hire men for some professions, particularly those requiring a high level of qualifications and experience. The female workforce is considered less stable than the male workforce (because women interrupt their career when having children, are less productive, less flexible and more expensive due to indirect costs).

Despite the fact that the increase in women's educational attainments has undermined the explanatory power of human capital theory, this theory has been questioned for other reasons by several authors (England 1982, 1985; Corcoran *et al.* 1984; Rosenfeld 1984; Rosenfeld and Spenner 1992). For example, the concentration of part-time working women in feminised occupations is more linked to structural constraints such as the absence of high-quality child care structures that are available at affordable prices rather than to human capital-related factors.

Social evolutions (the rise in women's level of education, of women's stronger integration in the labour market, the changes in family composition with the multiplications of single-parent households requiring

more women to become financially independent) should, according to neoclassical theories, lead to an improvement in women's training and professional experience, a higher level of female productivity and a better balance in the distribution of men and women in the labour market. However, segregation still persists.

1.2.1.2. The theory of intentional and statistical discrimination

This theory offers a different perspective. Discrimination occurs when an individual faces an unfair disadvantage due to certain characteristics shared by a certain section of the population which are judged independent of productive characteristics (Plassard 1987). Such discrimination may be intentional or not.

Intentional discrimination characterizes a situation where a voluntary discriminating behaviour results from biased preferences or personal interests. According to this theory (Becker 1971), an agent has perfect information regarding the market and does not want to be associated with persons who have characteristics that are considered as non desirable. This principle can be applied to gender discrimination (Bergman 1986, 1989): to recruit a woman could imply a "psychological cost" for the employer in case he has a discriminating preference for men.

Non intentional discrimination questions the hypothesis of perfect information and relies on informational asymmetry. Non intentional discrimination is often called statistical discrimination (Phelps 1972): an employer has imperfect information concerning the employees' productive characteristics. He will recruit a person on the basis of other signals that are supposed to approximate the information that is hidden or not observable (such as the color of skin, gender, culture…). There is no statistical ground for this type of employer behaviour.

In the case of gender discrimination, the employer is not able to distinguish women who will stay in the labour market in the long term from those who will quit rapidly. They then expect women's average productivity to be lower than men's and thus refrain from hiring women on the same terms as men. Such preconceptions against members of a certain group consequently have a negative effect on their labour market situation. Additionally, employers face higher information and projected future costs at times of recruitment and promotion.

1.2.1.3. The "job competition model"

The "job competition model" (Thurow 1975, 1979) is based on the fact that competences are not predetermined but essentially acquired on-the-job. The remuneration of an individual is linked to the job's characteristics, to the distribution of access chances to the job and also to the relative position in the hierarchy. Employers look at the level of education of the applicants for the job in order to select and rank them. They draw up a classification of the applicants' level of adaptability and their aptitude to be trained. The workforce is then allocated according to a parallel classification of applicants and jobs. An applicant with a high level of human capital will have a higher position on the waiting list. Employers select the most rentable and productive applicant and who requires the lowest training cost. Women are generally located at the end of the waiting list because their characteristics are less preferred by employers. Employers prefer to hire men as they are considered more suitable for the vacant job (Tijdens and Goudswaard, 1994).

According to this theory, applicants for a job continuously adapt to market requirements and raise their level of human capital in order to improve their productivity and consequently their wage. They will do so even if they are employed, in order to improve their position.

1.2.2. Institutional theories

According to these theories, some employees are forced to accept a less attractive and less well-paid job because there are no better opportunities in the labour market. This may be due to the segmentation of the labour market, the characteristics of the work organisation or the work environment. These theories

also rely on the hypothesis that institutions such as trade unions or public authorities play an important role with regard to employment and career development. Segregation between men and women partly originates in policies and general rules that are elaborated at a high organisational level and that are very often influenced by stereotypes.

1.2.2.1. The theory of the segmented labour market

The theory of the segmented labour market (Doeringer and Piore 1971; Piore 1973) states that the socioeconomic status of an individual in the labour market depends on labour market structures rather than on human capital. The labour market is dual with a primary sector (internal segment of the labour market) and a secondary sector (external segment of the labour market). The primary sector is characterised by hierarchised, relatively well remunerated, and protected employment and in this segment the rules of work are well defined and offer those professional opportunities (formation, evolution, promotion) that are necessary to ensure employment stability (Piore 1973). The secondary sector is characterised by low wages, as well as less security and career perspectives and less favourable job conditions. The employees in the secondary sector generally belong to disadvantaged groups.

Since women are usually considered as having a less stable professional trajectory than men, employers prefer to invest in male workers who have easier access to the internal segments of the labour market with the most interesting jobs. Companies from this sector are more likely to hire more educated employees with a higher level of experience and in general prefer to hire men (Conduto de Sousa 2005).

Segregation reflects this duality, women are concentrated in the secondary market, men in the primary. Moreover, employee mobility between segments is low. The difference between the two sectors is due to work quality and conditions rather than due to employees' qualifications.

1.2.2.2. Theories based on organisational and technological mutations

According to these theories, the characteristics of the work organisation and their interaction with the environment explain gender segregation (Kullis and Miller-Loessi 1992). The presence of women in an organisation depends on the characteristics of this organisation such as its size, its prestige, its relations with the public authorities, etc. On the other hand, workers' motivation depends on their position in the labour market and in the organisation itself. Since women are in less attractive jobs, they will be less motivated and more likely to quit their job, confirming the image of women as less reliable workers (De Meyer *et al.* 1999).

Other factors linked to the work environment have an impact on segregation (Cotter 1995) and can reduce it. The growth of the service sector, the decline of industry, and the rise in the level of education are all examples. The technological changes that have occurred over the last decades, such as the expansion of information and communication technologies, have increased the relative demand for skilled workers.

According to the "skilled-biased technological progress" theory, the contemporary technological evolution leads to a situation where qualified and non qualified workers become ever less substitutable. They have already negatively affected industry and low skilled workers; but have positively impacted upon the service (tertiary) sector and on qualified workers (Binamé et al. 1999). Technological changes tend to increase employment in the service sector where jobs are more accessible to women and to reduce employment in blue-collar jobs in industry that are more associated with the male workforce. Since women's level of education has increased more than men's (and has even become superior to men's), the technological evolution has had a favourable impact on women's employment and it has accelerated their arrival in traditionally male careers. Consequently, technological change has affected the professional composition of the female workforce (Black and Juhn 2000).

1.2.3. Radical and gender theories

Radical theories are based on the hypothesis that certain types of workers are in demand in the labour market whilst others are excluded. This selection depends on the production process but also on social and institutional factors. The market is thus characterised by a continuous movement of attraction and rejection of different segments of the workforce.

The odds of men and women being attracted/ rejected are determined by the characteristics that are attributed to each sex: women are responsible for the household and the family, the biological reproduction process of having and raising children, and workforce reproduction (taking care of the working partner). Women are thus more likely to be employed in jobs that are compatible with these roles (part-time jobs, for example). They hold jobs that are typically female and that offer few career opportunities (Sanders and Beeks 1993).

The first analysis of segregation as a consequence of entry barriers was carried out by Bergmann (1974). Bergmann's model of overcrowding explains how women's wages are depressed because female workers are overcrowded into a small number of occupations. Bans and restriction that still exist or that used to exist enhance such crowding.

Radical theories also explain segregation by the dominant position of men and by the fact that they have an interest in maintaining their privileged position by making it difficult for women to access high-level occupations. This situation is supported by informal agreements and preconceived ideas that are related to discrimination (Wyns and Van Meensel 1990).

Gender theories take into account a series of explanatory factors of professional segregation that have not been integrated in economic models and that are often considered by economists as exogenous (Conduto de Sousa 2005). The principal hypothesis is that the position of women in society and the family has a negative impact on women's situation in the labour market. These are consequences of the patriarchal system of social organisation. The jobs occupied by the female workforce depend on gendered stereotypes (Anker 1997) and on discrimination. Social attitudes and cultural prejudices are undoubtedly the determining factors of labour market behaviour. Some employers consider that women are generally less qualified than men, they attribute vacant jobs to men because these jobs are "masculine", or they prefer to hire women without children because they are believed to invest more in their jobs. Employers may also believe women to show more absenteeism or to be more likely to interrupt their careers (Lewis and Shorten 1991). Nevertheless, the hypothesis that direct and indirect costs are higher for women than for men has not been confirmed by any empirical evidence (Anker 1997). Sexual discrimination and the professional segmentation that comes from it create underemployment among women and an underutilisation of their intellectual capacities (OECD 2002).

At the end of the 90s, Akerlof and Kranton developed their identity theory assessing how a person's sense of self affects economic outcomes (Akerlof and Kranton 2000). Economic behaviour models are approached from a psychological and sociological stance. The inclusion of identity in modelling gender discrimination in the workplace substantively modifies the results of more traditional economic analyses. Gender is a universally familiar aspect of identity. The social categories "man" and "woman" have different ideal physical attributes and prescribed behaviours and one's identity is confirmed by following the social prescriptions for behaviour while not following these gives rise to anxiety and discomfort. Different actions thus pay off differently. People have identity-related payoffs from their own actions. "*Female trial lawyer, male nurse, woman marine – all conjure contradictions. Why? Because trial lawyers are viewed as masculine, nurses as feminine, and a marine as the ultimate man. People in these occupations but of the opposite sex often have ambiguous feelings about their work*" (Akerlof and Kranton 2000:721-722). But others' actions matter as well. "*A woman in a "man's" job makes male colleagues feel less like "men". To allay these feelings, they may act to affirm their masculinity and act against female co-workers*" (Akerlof and Kranton 2000:723). An identity theory of gender in the workplace broadens the economic understanding of occupational segregation. It explains changes in segregation over time by changes in societal notions of male and female.

Another explanation for the changes towards more or less gender segregation over time was developed by Goldin (2002). Goldin developed a theory that accounts for asymmetry in information, signaling and an inert system of social change and as such can be viewed as a hybrid of Becker's "taste" model combined with statistical discrimination. This theory has become known as the pollution theory. The basic idea is that when a firm recruits a woman worker this may cause the level of prestige of a previously all-male occupation to drop. "*The predictions of the model concern the range of segregated and integrated occupations with respect to a productivity characteristic and how occupational segregation changes as the distribution of the characteristic becomes more similar among women and men*" (Goldin 2002:1). Pollution theory ascribes discrimination to men's desire to safeguard their occupational status or prestige (a desire that is distinct from their preoccupation with their earnings). Occupational status or prestige derives from a productive characteristic of which some level is needed to enter a particular occupation. It can be "polluted" if an individual enters the occupation who is evaluated on the grounds of the average characteristics of the group he or she belongs to rather than on the basis of individual merits. For example, when a woman with the required qualifications enters an all-male occupation, she may be seen as "polluting" the occupation because her entry might signal to the rest of society that the occupation has altered. Such signaling is possible because society has imperfect information regarding technological change and is limited in its judgment on observables, of which sex is an important one. Pollution theory is thus heavily dependent on the existence of asymmetric information: women know their characteristics and so do employers that recruit them - but others in society do not. The model illustrates that the relationship between occupational segregation and the level of the productive characteristic that conditions entry to the occupation is U-shaped, segregation being highest at the tails of the female characteristic distribution. The model further shows how earnings and discrimination respond to changes in the male/female distributions of the characteristic.

From a feminist stance, Badgett and Folbre (2003) have shown there to be a link between segregation and the marriage market. The idea is that segregation is observed by women who in response to it expect to find employment primarily in low-skilled occupations and thus underinvest. Each occupation has an "aura of gender". Non-conforming individuals to these social prescriptions may be less attractive to potential partners and thus experience greater difficulty on the marriage market. Since women depend on partner income more than men, this penalty may lead them to underinvest in the human capital that is required to enter male occupations. This is an example of self-inflicted discrimination rooted in marriage rather than the labour market.

Such self-inflicted discrimination is also allowed for in Baldwin *et al's* (2001) model. Just like Becker, these authors assume a fully competitive world, with an occupational hierarchy based on human capital required and wages to remunerate human capital investment Unlike Becker, these authors allow for individuals with varying ability, the most able workers enjoying wage rents. Male workers, having a positive taste for discrimination against high-ranked female professionals, are granted a financial reward for accepting such female superiors. Part of the rent a high-ranked woman receives is thus devoted to compensate for the distaste of the male workers she supervises. The level of this reward or compensation is determined by technology, the strength of male workers' taste discrimination, the number of men a woman manages and the wage level that corresponds to men's place in the occupational hierarchy.

1.3. Measures and indicators

There are different methods to measure segregation: based on descriptive statistics or on indices. Descriptive statistics allow one to calculate the ratio between the percentage of women in a profession/sector and the percentage of women in the labour force, in order to identify if they are over or under represented. These methods can be applied in the same way to provide evidence of professions dominated by men.

The most used method to measure segregation is the calculation of indices, Maron and Meulders (2008) present the following 6 indicators:

1) The dissimilarity index is the most used indicator to measure inequalities (ID Index) defined as: the "sum of the minimal proportion of women and minimal proportion of men that should change profession so that the proportion of women is identical in every profession" (Anker, 1998). The Index of Dissimilarity (ID) is arguably the most widely used for international comparisons - it was proposed as early as 1955 (Duncan and Duncan 1955). This indicator calculates the professional or sectoral repartition of employment by gender, associated with vertical and horizontal segregation respectively (Anker, 1998). This index measures the distance from an equal distribution of men and women across occupations, the hypothesis being that segregation implies a different distribution of men and women over all professional occupations. The more this distribution is equal, the lower is segregation.

   The index lies between 0 and 1: 0 in the case of no segregation, and 1 in the case of total segregation, each profession being entirely dominated by women or by men. It also allows calculating the number of men or women that need to change sector/occupation in order to have an equal distribution of gender in the labour market. The value of the ID index depends on the level of female employment, but only indirectly, via changes in the occupational structure that accompany increases or decreases in the proportion of women in the workforce.

   This index can however present some limits since it is based on the hypothesis that there should be an equal distribution of men and women in every sector or occupation.

2) The standardised index constructed by Karmel and MacLachlan (1988) (Index IP) is also based on the hypothesis that segregation implies a different distribution of men and women over professional occupations. It can be interpreted as the share of the employed population that would need to change occupation (sector) in order to bring about an even distribution of men and women among occupations or sectors. The index ranges from 0 in case of complete equality to 0.5 in the opposite case. Because the value of the IP depends on how high the female share of employment is, studying change over time can be problematic, since the recorded level of segregation could increase or decrease solely in response to changes in women's share of total employment.

Both the IP and the ID indices assume that segregation results in a different distribution of women and men across occupations or sectors: the less equal the distribution, the higher the level of segregation.
These two indices are the most commonly used in the literature. However, other indices with different statistical characteristics exist. We present them hereafter in order to provide a comprehensive overview.

3) The index of Moir and Selby-Smith (MSS Index), also called the "Women Employment Index" is based on the understanding that segregation means that the proportion of women within the occupational categories is different from the proportion of women in employment. This indicator measures the sum of the absolute difference of the proportion of women and the proportion of employed over occupations. This index equals 0 in the case of complete equality, and twice the male share of employment ($2 * M/N$) in the case of complete dissimilarity. It can be interpreted as the proportion of persons in employment who should change from sector/occupation in order to achieve a completely equal distribution. However, a change in the index may be due to a change in dissimilarity but it can also derive from a change in the proportion of women in employment – eventually to a combination of the two.

4) The "Sex Ratio index" (SRI) can be defined as the number of women occupied in feminine sectors/occupations divided by the number of women that would work in these professions if there were no segregation minus the number of women occupied in masculine sectors/occupations divided by the number of women that would work in these professions if there were no segregation.

According to Emerek et al. (2002), these different measures of segregation are however not totally satisfying when measuring segregation over time because a modification of the distribution of women and men over occupations is not very probable in a context where the occupational structure is stable as well

as the share of women in employment. How can changes in the level of women's employment and their share in the occupational structure be simultaneously accounted for?

5) The Gini Coefficient is generally used to measure income inequality but can be applied to measure segregation (James and Taeuber, 1985; Silber, 1989). Contrary to the other indicators, this coefficient takes into account the repartition of sectors/occupations according to the degree of concentration of men and women.

6) Marginal matching (MM) consists in a subdivision of feminine and masculine sectors/professions. It is supposed that the feminine sectors/occupations have the same number of workers as there are women in employment and that the masculine sector/professions have the same number of workers as there are men in employment. This indicator lies between 0 and 1: 0 when there is no segregation and no possible distinction between feminine and masculine jobs; and 1 when segregation is maximal, when feminine occupations are largely occupied by women and masculine occupations by men. This method allows classifying the data without the statistical process being biased by non pertinent factors (De Meyer et al. 1999), by isolating the changes in the labour market (such as a growth of the female or male employment rate) so that they cannot affect the measure of segregation.

Each of these indicators has its advantages and disadvantages. According to Siltanen et al. (1995), only marginal matching (MM) satisfies all criteria to measure the degree of segregation.

"*Bridges, who has recently proposed a new index, has spoken of 'the battle of indices showing signs of fatigue' (Bridges 2003: p.564) to refer to the voluminous and still growing literature on the measurement of segregation. It is generally accepted that no single index is fully satisfactory, and that different indices are appropriate for different purposes*" (Bettio and Verashchagina, 2009, p. 15).

With respect to the indicators used to evaluate the European Employment Strategy, the European Employment Committee adopted the Karmel and MacLachlan (1988) index (IP) to measure and monitor gender equality. The Committee proposes one indicator: gender segregation in occupations/sectors, calculated as the average national share of employment for women and men applied to each occupation/sector; differences are added up to produce a total amount of gender imbalance presented as a proportion of total employment (ISCO classification / NACE classification).

It is however worth noting that: *"Regarding this issue, large methodological problems still exist. The problems of measuring segregation lie primarily in the use of a single figure for a complex process. The fact that a positive relationship between the level of female employment and the level of segregation exists is an example of this. Another reason for being sceptical […] is that the reduction of segregation should be treated as a long-term process which makes segregation indices unsuitable for monitoring year to year progress. Finally, and perhaps most fundamentally, it is not clear whether segregation indeed refers to an aspect of gender (in)equality. If it does, segregation is implicitly connected with restrictions and the impossibilities of making a free choice. It is not clear, however, whether this is indeed the case and whether in a real 'gender equal' world all segregation should vanish. Together, these factors make […] not very relevant indicators for measuring the extent of gender equality in the field of employment.*" (Plantenga and Remery, 2003, p. 18).

According to Bettio and Verashchagina (2009), segregation is best measured and analysed for occupations rather than for sectors. First, because employment decisions are taken more with respect to jobs (rather with respect to sectors), second, because each sector tends to include very different types of jobs.

It is worth mentioning a study from Jones (1999) on the data from 56 nations that shows that measures of nominal segregation are not equivalent to measures of hierarchical inequality. Measures of nominal segregation ignore the ranking of occupations, and measures of ordinal inequality take the vertical ordering of jobs into account. Nominal segregation seems to increase with industrialization and the expansion of service industries but decreases as female labour force participation increases. By contrast,

occupational inequality seems to decrease with industrialization and the expansion of services but to increase as both female labour force participation and level of educational inequality rise. Nominal segregation and ordinal status inequality are interrelated. Where nominal segregation is high, women's relative representation in high status occupations tends to rise. Jones argues that occupational segregation should not be equated with occupational inequality, and that theoretical propositions regarding gender-occupational segregation may not be applicable to issues concerning occupational inequality. A better understanding of, and insight into the nature of gender-occupational differentiation can be reached by simultaneously considering these two dimensions of gender-occupational differentiation.

"*The main data sources for measurement of segregation are two series from the European Labour Force Survey (LFS): employment by occupations (ISCO-88 3-digit) and by sectors (NACE 2- digit). Both series are available for different intervals for different countries, starting from 1992*" (Bettio and Verashchagina, 2009, p.16).

Concerning vertical segregation, Blackburn and Jarman (2005) propose a decomposition measure of the vertical component of segregation. "O*verall segregation (O, measured by the Gini coefficient) is broken down into a vertical component (V, measured by Somers' D) capturing the association between segregation and a specific dimension of inequality (such as income, for example) and a neutral or non-invidious horizontal component (H*)" (Bettio and Verashchagina, 2009, p. 48). This measure has however been criticised by the fact that the two components are conflated (Watts, 2005).

1.4. Results of European comparisons

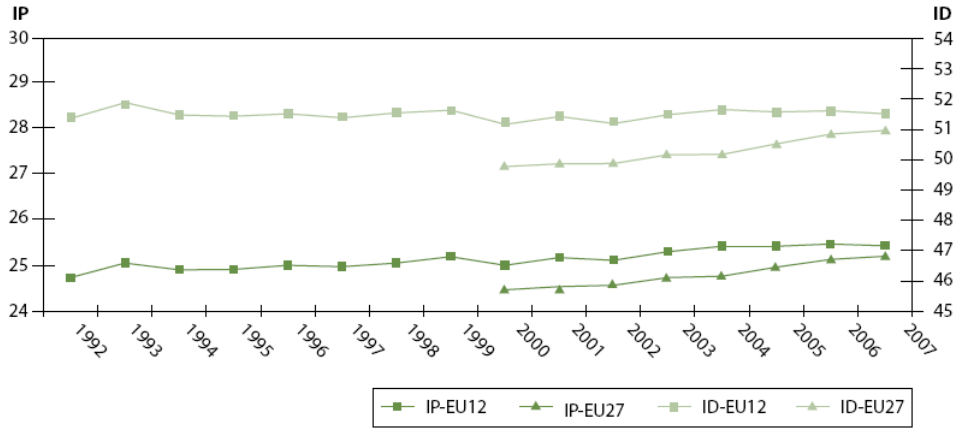
If the participation rates of women and men in Europe tend to grow closer, the level of segregation remains high (Anker, 1998) and stable (England, 1981; Reskin and Hartmann, 1986; Jacobs, 1987; Hakim, 1994; Jonung, 1998). Segregation exists in all European countries. However, differences can be observed among countries depending on different factors. The following chapter is based on a recent European comparison of segregation (Bettio and Verashchagina 2009).

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 90s onwards. Segregation remains high and has changed little since the early 1990s. According to the authors: "*A slight upward trend in segregation is detectable, with an increase of about one percentage point in the index for the EU12 area since 1992, and for the EU27 area since 1997.The upward trend over the current decade is somewhat more pronounced for sectoral, gender-based segregation" (Bettio and Verashchagina; 2009, p.7).*

Figure 2 presents gender occupational segregation in the different European countries in 2007. It shows that on average gender occupational segregation was 25,2% in 2007 in the EU on average (based on the IP index). This number represents the share of the employed population that would need to change occupation (sector) in order to bring about an even distribution of men and women among occupations or sectors. The countries that present the highest levels of segregation are Estonia (32.2%), Slovakia (30.3%), Latvia (30.1%), Finland (29.5%) and Bulgaria (29.3%). The countries that show the lowest levels of segregation are Greece (22.4%), Romania (23.3%), Malta (23.6%), Italy (23.6%) and The Netherlands (25.2%). The difference between the highest and the lowest segregated countries is about 10 percentage points.

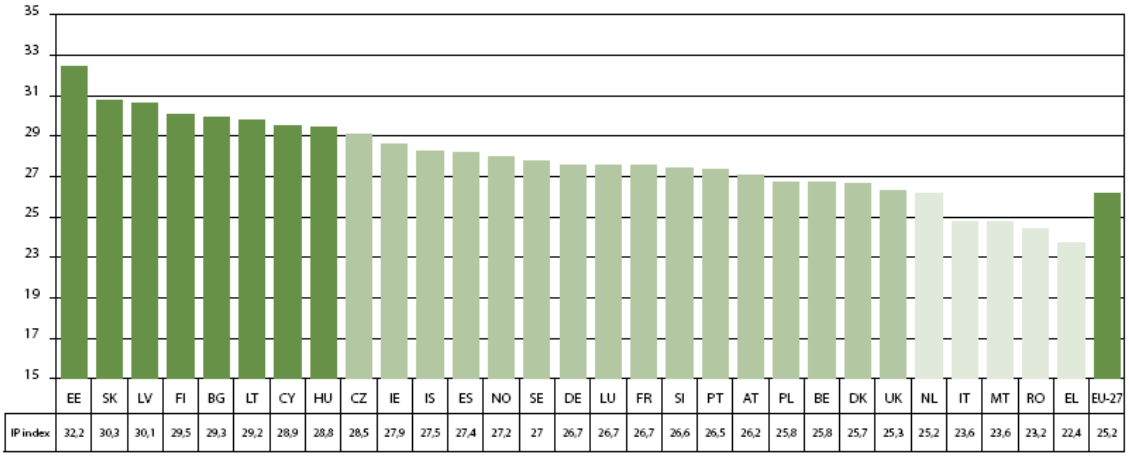
A different picture appears from Figure 3 showing segregation across sectors of economic activity. The countries that present the highest levels of segregation are Estonia (26.1%), Latvia (23.5%), Lithuania (23.4%), Ireland (23.3%) and Slovakia (23.2%). The countries that show the lowest levels of segregation are Malta (14.9%), Greece (15.9%), Romania (13.1%), Slovenia (17.4%) and Italy (17.87%). The difference between the highest and the lowest segregated countries is 12.8 percentage points. The European average appears to be lower with gender sectoral segregation at 18.4%.

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



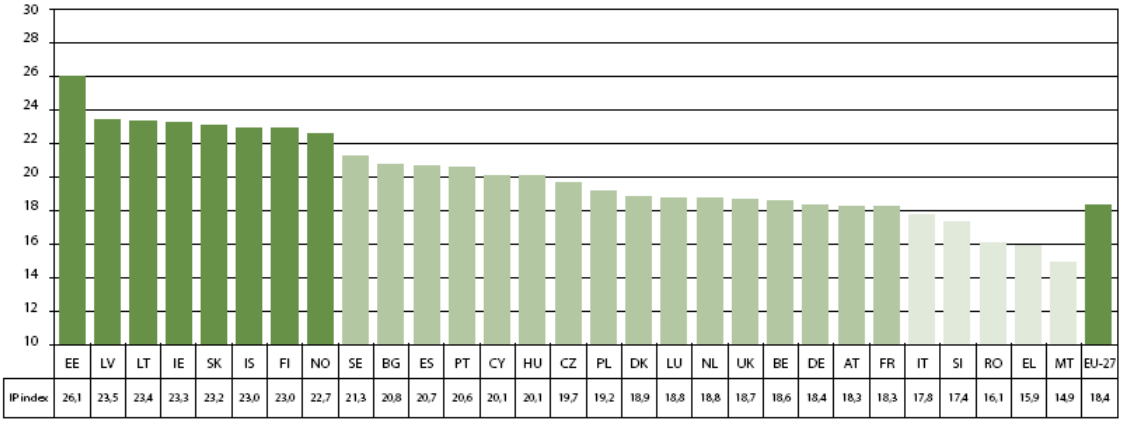
Source: Bettio and Verashchagina (2009, p. 32)

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 and Verashchagina (2009, p. 33) using LFS (ISCO-88 3-digit).

Figure 3: Gender sectoral segregation in Europe, 2007

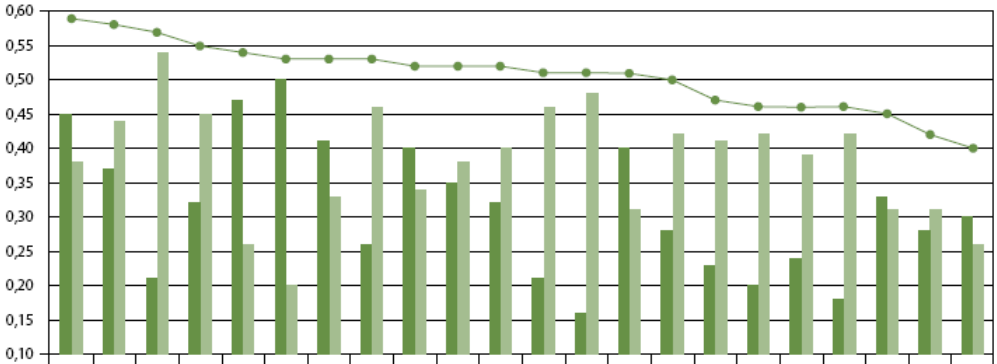


NB: Countries are grouped, according to the level of the IP index, into high/low-segregated, with the IP index accordingly being higher/lower than mean+MAD/mean–MAD (19.97+2.14/19.97-2.14); the residual is a middle group
Source: Bettio and Verashchagina (2009, p. 34) using LFS (NACE two-digit).

Bettio and Verashchagina (2009) in their study comment on the trends in gender occupational segregation in Europe over the last decade: "*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 ones, have actually experienced an increase in segregation. Desegregating countries are Sweden, Norway, Denmark, the UK, Austria, Czech Republic and Iceland, whereas re-segregating countries are Romania, Bulgaria, Italy, Ireland, Latvia, Spain.*" They continue by explaining that: "*With the exception of a few countries, mixed occupations have increased over the past decade in all the countries where segregation indices declined, and conversely. Across countries, change has been more pronounced for male-dominated occupations, whose share has decreased proportionately more*." (p. 32)

Bettio and Verashchagina (2009) also present a comparison of vertical and horizontal segregation across Europe (Figure 4). In the majority of countries (14 out of 21) vertical segregation is lower than horizontal segregation. However, there are large cross-country differences.

Figure 4: Horizontal, vertical and overall segregation in Europe, 2006



	EE	DK	LU	FR	SK	CZ	SE	NL	LT	NO	UK	ES	IE	CY	AT	HU	FI	BE	SI	DE	PL	IS
Vertical	0.45	0.37	0.21	0.32	0.47	0.5	0.41	0.26	0.4	0.35	0.32	0.21	0.16	0.4	0.28	0.23	0.2	0.24	0.18	0.33	0.28	0.3
Horizontal	0.38	0.44	0.54	0.45	0.26	0.2	0.33	0.46	0.34	0.38	0.4	0.46	0.48	0.31	0.42	0.41	0.42	0.39	0.42	0.31	0.31	0.26
Overall	0.59	0.58	0.57	0.55	0.54	0.53	0.53	0.53	0.52	0.52	0.52	0.51	0.51	0.51	0.5	0.47	0.46	0.46	0.46	0.45	0.42	0.4

Note: the criterion for vertical segregation is pay inequality measured by the percentage of male workers in the occupation with average gross hourly income higher than the average gross male hourly income in the economy.
Source: Bettio and Verashchagina (2009, p. 49) using EU-SILC 2006 (ISCO-88 2-digit).

This report on gender segregation in the labour market in general states that segregation is higher in low-paid occupations than in high-paid ones. Case studies show that the choice of study field, stereotypes, the unequal care burden and the consequent inability to prioritize income commitment, the search for shorter working hours and the covert biases or forms of impediments in organisational practices constitute important factors that are linked with segregation (Bettio and Verashchagina, 2009, p. 9). The influence of these factors varies across countries and national contexts but also across sectors. In general, a positive correlation has been observed between the level of women's employment rate and the level of segregation.

In the framework of the European Employment Strategy launched in 1997, indicators are used in order to assess Member States' progress on implementing the Employment Guidelines. The ID index is retained for measuring segregation in the Member States (gender segregation in occupations and in sectors). This indicator is "*calculated as the average national share of employment for women and men applied to each occupation/sector; differences are added up to produce a total amount of gender imbalance presented as a proportion of total employment (ISCO classification/NACE classification)*" (p. 58). Table 1 presents the data on gender occupational segregation and Table 2 on gender sectoral segregation for the years 2000 to 2008.

Table 1: Gender segregation in occupations

	2000	2001	2002	2003	2004	2005	2006	2007	2008
EU27	25.3	25.3	25.3	25.5	25.5	25.9	26.0	26.0	26.0
EU15	25.8	25.8	25.7	25.9	26.0	25.9	25.9	25.9	25.8
BE	26.7	26.1	25.3	26.3	26.7	26.2	26.1	25.7	26.2
BG	27.4	27.0	27.1	27.8	27.4	27.8	28.7	29.4	29.4
CZ	30.1	29.2	29.6	29.4	28.9	28.4	28.1	28.5	28.5
DK	27.9	28.1	28.3	27.4	27.5	26.9	27.8	25.7	26.5
DE	26.9	27.0	26.9	26.7	26.7	26.5	26.5	26.5	26.1
EE	31.3	32.4	30.4	32.1	32.7	30.8	31.6	32.2	32.2
IE	26.9	26.7	26.9	27.1	26.8	27.2	27.8	27.9	27.6
EL	21.0	21.5	21.6	21.7	22.5	22.5	22.4	22.4	22.4
ES	24.6	24.9	25.3	26.4	26.2	26.6	27.1	27.4	27.3
FR	27.0	26.6	26.3	26.3	26.7	26.1	26.5	26.7	26.6
IT	21.6	21.9	21.8	22.3	23.3	23.9	23.7	23.6	23.8
CY	28.7	29.5	28.8	28.6	29.5	30.6	29.3	28.9	28.0
LV	28.7	29.7	28.6	27.8	27.2	27.1	29.4	30.2	29.8
LT	28.1	28.4	27.3	27.5	27.9	27.4	29.4	29.2	30.1
LU	28.7	26.8	27.1	24.7	25.7	26.4	26.3	27.2	29.2
HU	28.1	28.3	28.1	28.8	28.6	28.4	28.8	28.8	28.2
MT	19.6	17.2	24.5	23.8	24.1	24.3	24.3	23.2	24.9
NL	24.8	25.0	24.5	25.3	25.7	26.2	25.6	25.0	24.9
AT	27.3	27.2	27.8	27.7	25.8	26.0	25.9	26.2	26.1
PL	25.3	25.6	25.3	25.2	25.4	25.5	25.5	25.8	26.2
PT	26.4	26.3	27.6	27.4	26.0	25.9	26.5	26.5	27.3
RO	12.0	11.8	11.9	11.8	11.7	22.3	22.8	23.2	22.9
SI	26.9	26.8	27.1	27.2	27.2	27.6	26.8	26.3	26.7
SK	31.2	31.2	30.8	30.5	30.7	29.5	29.9	30.3	30.5
FI	30.0	29.6	29.4	29.5	29.3	28.9	29.0	29.5	29.5
SE	29.0	28.0	27.8	27.7	27.6	27.4	26.8	26.9	27.0
UK	26.7	26.8	26.5	26.5	26.3	25.8	25.5	25.1	24.8

Source: European Commission (2009), « Indicators for monitoring the employment guidelines - 2009 compendium », DG Employment, Social Affairs and Equal Opportunities.
Notes: LU 2003, 2004 and 2005:Annual average data. RO until 2004 based on ISCO 1 digit
Data lack comparability due to changes in certain survey characteristics :
- between 2002 and 2003 for FR and LU.
- between 2003 and 2004 for IT and AT.
- between 2004 and 2005 for DE, ES and SE.

The European average for gender occupational segregation remains stable over the period for the group of EU15. On the contrary, the average for the EU27 rises from 25.3% in 2000 to 26% in 2008. Occupational segregation is therefore likely to be somewhat higher among the new entrants that among the « old » member states. However important disparities are observed among countries. For example, in the case of Romania, the level of gender segregation appears to be lower than the EU27 average. One can also observe different patterns of evolution of occupational segregation. While some countries show an improvement in the level of occupational segregation, others present the contrary (the level of segregation increases). One cannot conclude that there is a general trend over the period that is observed in all countries.

Table 2: Gender segregation in sectors

	2000	2001	2002	2003	2004	2005	2006	2007	2008
EU27	17.7	17.7	17.8	18.1	18.5	18.5	18.7	18.9	19.4
EU15	18.1	18.1	18.2	18.4	18.5	18.5	18.7	18.8	20.3
BE	17.8	18.1	18.2	19.2	18.8	18.1	18.3	18.6	19.3
BG	17.6	17.5	18.1	19.3	19.0	19.2	19.6	20.8	21.9
CZ	19.7	18.9	19.3	19.5	19.2	19.1	19.1	19.7	19.1
DK	19.8	19.0	18.5	18.3	19.1	18.7	19.4	18.9	19.3
DE	18.3	18.2	18.1	18.2	18.1	18.2	18.2	18.4	18.3
EE	24.0	24.4	22.5	24.0	22.8	23.7	24.3	26.1	25.8
IE	20.4	20.7	21.0	21.1	21.4	22.4	22.7	23.3	22.5
EL	15.0	15.4	15.4	15.9	15.8	15.9	15.9	15.9	15.5
ES	18.9	19.3	19.5	20.2	20.2	20.4	20.4	20.7	20.7
FR	17.4	17.4	17.5	17.2	17.1	17.1	17.9	18.3	18.0
IT	15.2	15.2	15.4	15.7	17.8	17.9	17.8	17.8	18.0
CY	18.2	17.5	18.1	18.1	19.5	20.9	19.6	20.1	20.3
LV	17.5	21.0	21.7	20.9	21.7	21.0	23.8	23.5	22.8
LT	18.9	20.8	21.5	21.9	21.9	22.4	23.1	23.4	22.9
LU	17.8	19.6	19.7	18.6	17.7	17.4	18.3	19.0	18.9
HU	19.5	19.3	19.5	19.7	19.7	19.8	19.9	20.1	19.4
MT	15.9	15.2	18.0	15.9	14.9	15.2	16.3	14.6	15.6
NL	18.1	18.1	16.7	18.0	17.6	17.5	18.0	17.9	17.9
AT	20.1	20.3	20.4	20.8	18.9	18.3	19.3	18.3	18.4
PL	13.8	13.9	13.7	14.1	18.7	19.0	19.4	19.2	20.2
PT	21.5	21.2	22.2	22.0	20.4	20.5	20.4	20.6	21.7
RO	13.6	13.8	14.6	14.3	14.7	15.0	15.5	16.1	16.9
SI	17.2	17.4	17.6	17.8	17.8	18.3	17.8	17.2	19.2
SK	21.9	22.8	22.5	22.7	22.6	22.4	22.8	23.2	23.5
FI	22.5	21.9	21.6	21.9	22.3	22.2	22.7	22.9	23.1
SE	21.8	21.2	21.5	21.6	21.4	21.6	21.6	21.3	22.1
UK	18.8	18.8	18.9	18.9	18.8	18.5	18.5	18.5	18.2

Source: European Commission (2009), « Indicators for monitoring the employment guidelines - 2009 compendium », DG Employment, Social Affairs and Equal Opportunities.
Notes: LU 2003, 2004 and 2005: Annual average data.
Data lack comparability due to changes in certain survey characteristics :
Data updated in June 2009
- between 2004 and 2005 for DE, ES and SE.
- between 2001 and 2002 for RO
- between 2002 and 2003 for FR and LU.
- between 2003 and 2004 for IT and AT

In the case of gender sectoral segregation, the EU15 average has risen over the period from 18.1% in 2000 to 20.3% in 2008. It is lower in the EU27 than in the EU15 so that sectoral segregation appears to be lower (on average) in the new entrants. Gender sectoral segregation has remained stable or increased in almost all countries over the period. The only exceptions are UK, Austria, Denmark and the Czech Republic.

To conclude this part of the report, we draw attention to the fact that segregation persists everywhere. Segregation has stagnated at best over recent years although most countries have seen an increase in both horizontal and vertical segregation. There is thus no evidence of a spontaneous movement towards less segregation in all European labour markets.

2. Gender segregation in science

In the first section of this report we provided a general overview of gender segregation on the European labour market as a whole. In this section, we focus on gender segregation (horizontal and vertical) in science and research. First, we present the results from "She Figures" (2009), (EC, 2009b) comparing them with "She Figures" (2003) (EC, 2004) in order to comment on the evolution of segregation in science and research over recent years. The first part focuses on horizontal segregation and the second part on vertical segregation. In order to compare segregation among researchers with segregation in the total workforce, we have computed Dissimilarity indices for these two populations. Their analysis figures at the end of section 2.1.2.

It is important to keep in mind that there are important institutional differences between countries regarding their educational and academic systems. This makes comparisons difficult. Caution is required when interpreting cross-country differences in numbers.

2.1. Horizontal segregation

2.1.1. Women employed in research

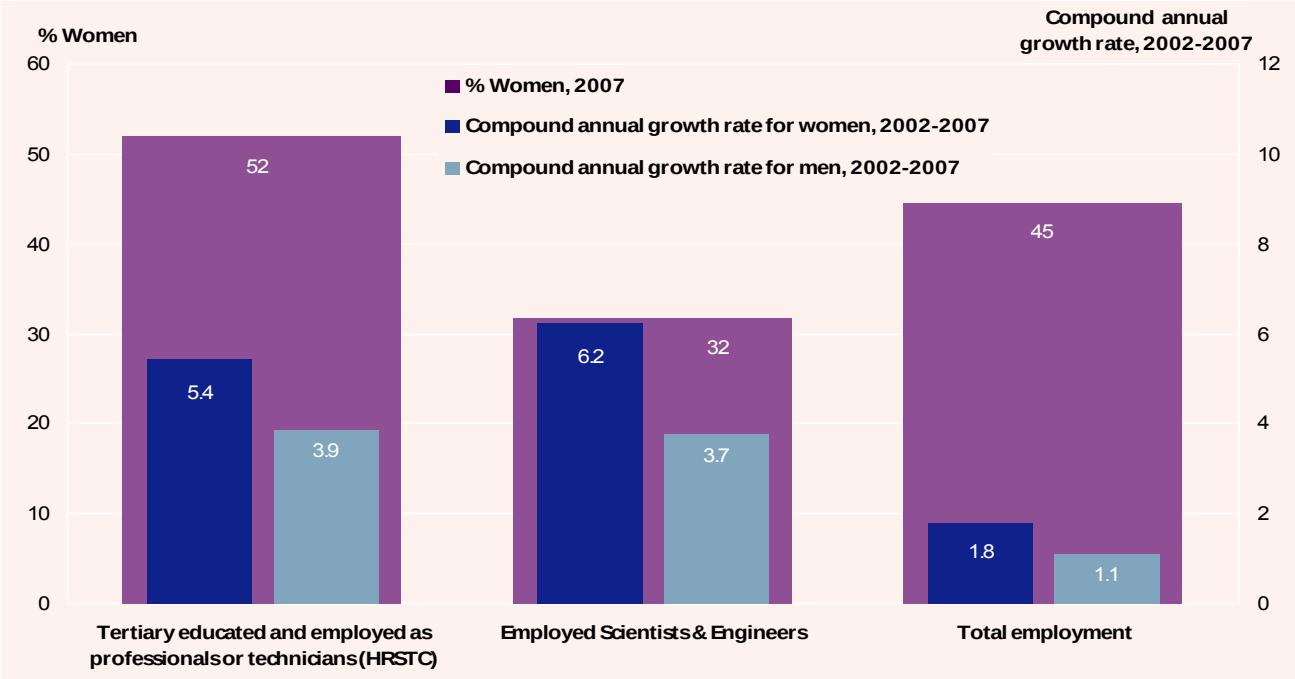
Figure 5 compares the proportion of women in total employment with their share amongst the highly educated employed as professionals or technicians[1] and amongst those working as scientists and engineers [2] for the year 2007. "*The fact that the proportion of women is higher amongst highly educated professionals or technicians (52%) than in total employment (45%) illustrates the fact that tertiary educated women are more successful than the others in finding a job. However, their proportion lowers to 32% in the group of employed scientists and engineers which in turn exemplifies the problem of gender segregation in education. Between 2002 and 2007, women have been catching up with men as women's compound annual growth rate has exceeded that of men both in total employment and in the two more precise subgroups. The difference is largest amongst scientists and engineers where the share of women has annually grown by 6.2% on average between 2002 and 2007 compared with a male growth rate of just 3.7%. These growth rates are respectively 5.4% and 3.9% for highly educated women and men working as professionals or technicians" (She Figures 2009, EC, 2009b p. 20)*. This growth rate is thus higher for these categories than for the total employment where it is limited to 1.8% for women and to 1.1% for men.

The same is observed for the compound annual growth rate of the numbers of female and male scientists over the period 2002-2007. Women tend to catch up with men over time. The number of female researchers has increased at a faster rate than the number of men during the period (except for the Czech Republic, Romania, Bulgaria, Hungary, Latvia and France). In the EU-27 on average, the number of female researchers has increased at a rate of 6.2% per year compared with 3.7% for male researchers (Figure 5). Moreover, "*given that the mean growth rate for women is higher in the EU-15 than in the EU-27 whereas both geographical entities put forth the same growth rate for male researchers, it appears that in the EU's most recent member states, the share of women in research is increasing at a slower pace than in the older member states*" (She Figures 2009, p. 21, EC, 2009b).

[1] "Technicians and associate professionals" (ISCO-3) are defined as follows: "*occupations whose main tasks require technical knowledge and experience in one or more fields of physical and life sciences, or social sciences and humanities. The main tasks consist of carrying out technical work connected with the application of concepts and operational methods in the above-mentioned fields, and in teaching at certain educational levels*" (p. 127, She Figures, 2009, EC, 2009b).

[2] The group "Scientists and Engineers" includes the Physical, mathematical and engineering occupations (ISCO '88 COM code 21) and the Life science and health occupations (ISCO '88 COM code 22).

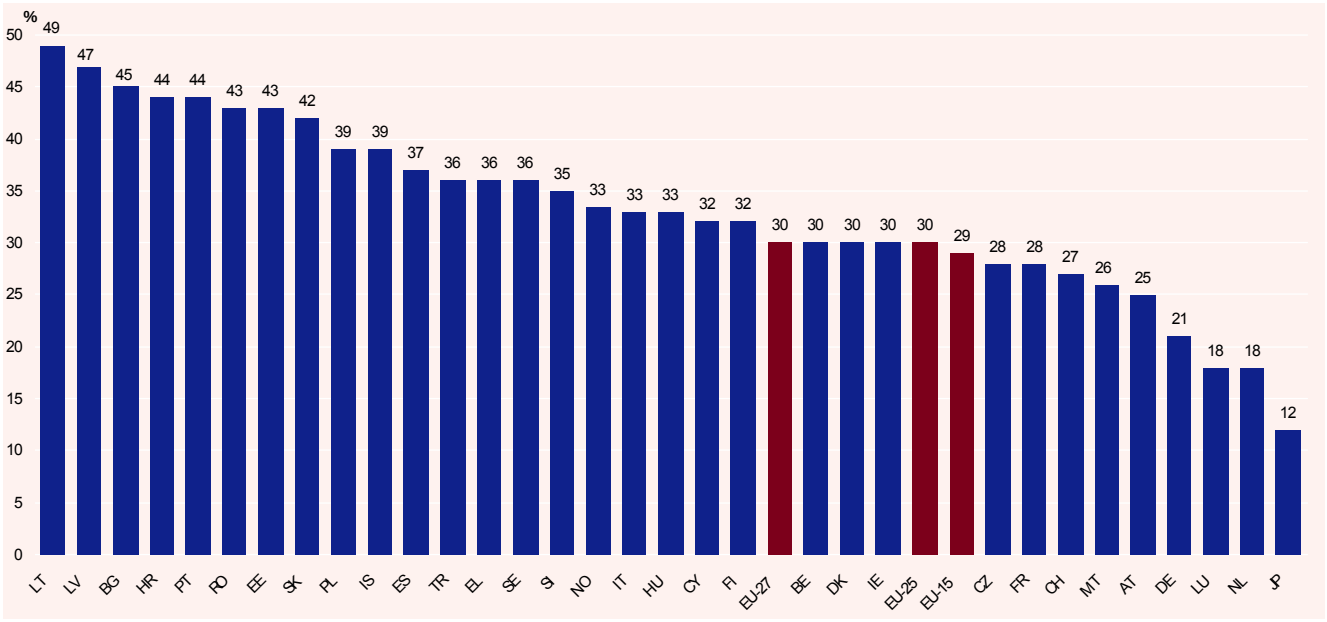
Figure 5: Proportion of women in the EU-27 for total employment, tertiary educated and employed (HRSTC) and scientists and engineers in 2007, compound annual growth rate for women and men 2002-2007



Source: She Figures, 2009 p. 25, (EC, 2009b) , on the basis of the Labour Force Survey, HRST statistics (Eurostat)
Data estimated: EU-27 estimated by Eurostat (2002 - Employed Scientists & Engineers)

Figure 6 presents the proportion of female researchers by country. The average proportion of female researchers in the EU-27 is 30% in 2006. At the top of the ranking of the proportion of women in research, there is Lithuania (49%), followed by Latvia (47%), Bulgaria (45%), Croatia (44%) and Portugal (44%). In general, Baltic States and Eastern countries show very high level of representation of women in research. At the end of the scale, there is the Netherlands and Luxembourg with 18% of women among researchers.

Figure 6: Proportion of female researchers, 2006



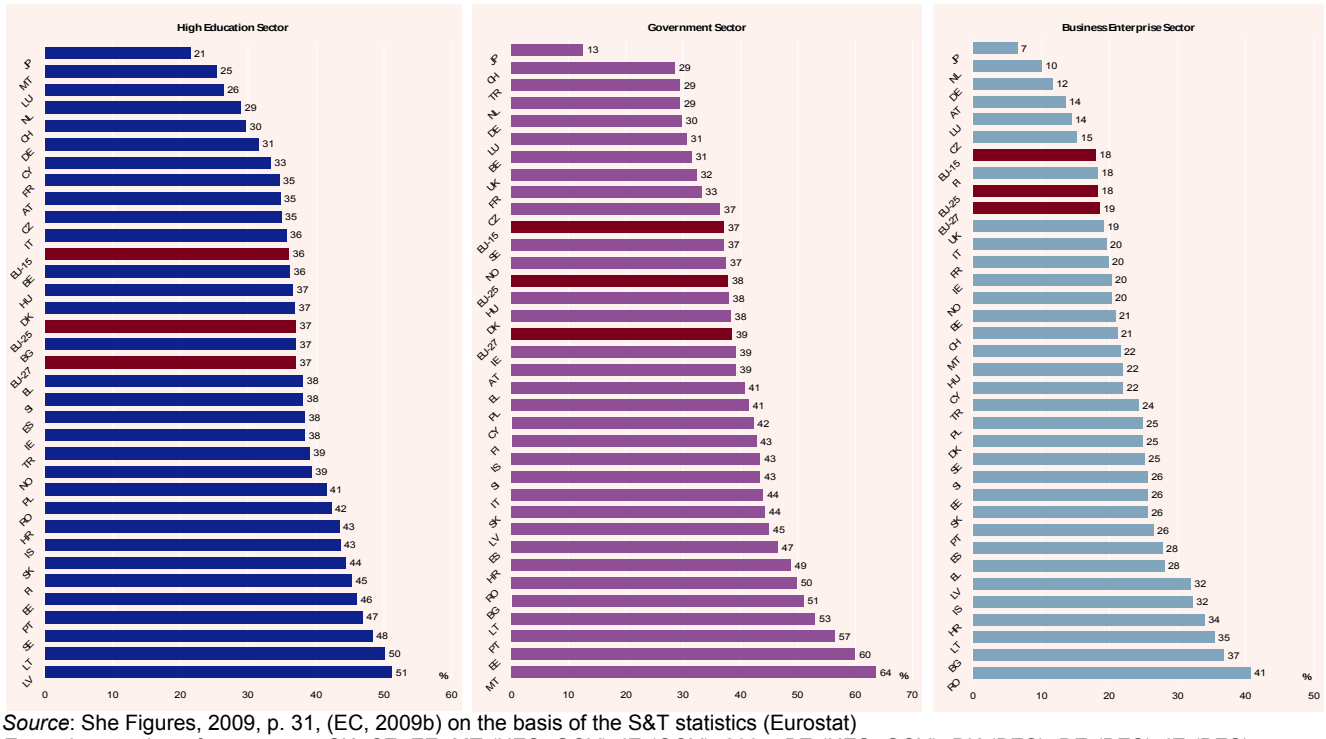
Source: She Figures, 2009, p. 28 (EC, 2009) on the basis of the S&T statistics (Eurostat), Norwegian Institute for Studies in Innovation, Research and Education
Exceptions to the reference year: CZ, EE, SK, NO: 2007; BE, DK, DE, IE, EL, LU, NL, PT, SE, IS, JP: 2005; CH: 2004
Data unavailable: UK, IL
Provisional data: NL
Data estimated: EU-27, EU-15 (by Eurostat), EU-25 (by DG Research), EE
Head count

An analysis by sectors (higher education, government and business enterprises sectors) shows a very similar presence of women in the public and in the higher education sectors and a considerably lower presence in the private and business sector (Figure 7). On average in the EU-27, women represent 37% of researchers in the higher education sector, 39% in the government sector but only 19% in the business and enterprise sector. The degree of cross-country disparity is very similar in higher education and public enterprise but much larger in private enterprise. In all sectors two countries systematically show a low proportion of female researchers, the Netherlands and Japan,[1] whereas Lithuania and Romania consistently have the highest proportions of women in research.

The data presented in She Figures 2003 allows one to compare the evolution of the percentage of women researchers by sector with the EU-15 (Figure 8 compared with Figure 7). For the higher education sector, this proportion was 34% in 2000. The evolution was even stronger in the government sector where the percentage was 31% in 2000. Finally, the percentage of women researchers in the private sector stood at 15% in 2000.

[1] However, there are other countries in this situation as regards the higher education sector (Malta, Luxembourg, Switzerland) and the government sector (Switzerland, Turkey, Germany).

Figure 7: Proportion of female researchers by sector, 2006

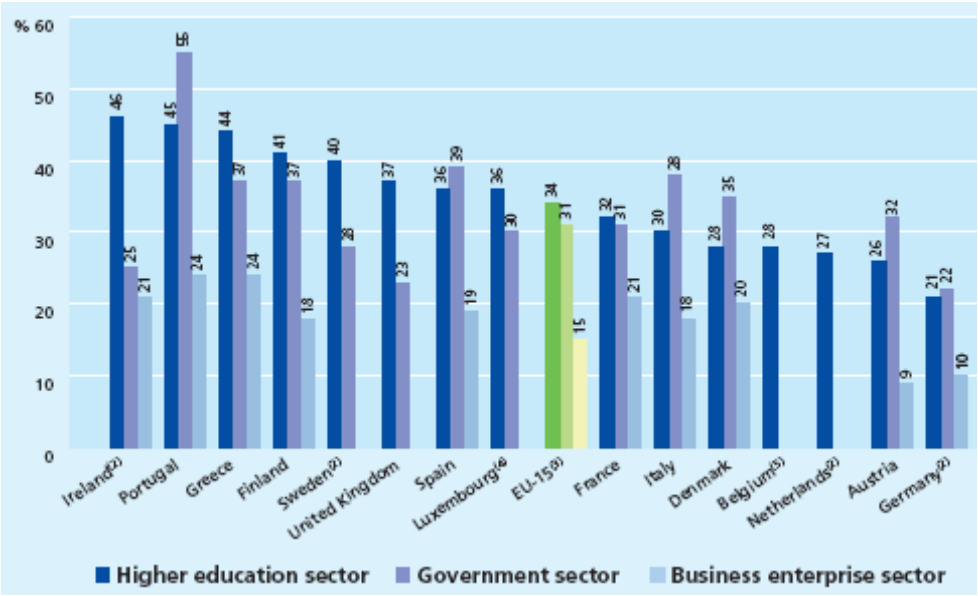


Source: She Figures, 2009, p. 31, (EC, 2009b) on the basis of the S&T statistics (Eurostat)
Exceptions to the reference year: SK, CZ, EE, MT (HES, GOV), IE (GOV): 2007; BE (HES, GOV), DK (BES), DE (BES), IE (BES), EL, LU, NL, PT, SE, IS, NO, JP: 2005; CH (HES, BES): 2004
Data unavailable: IL, UK (HES)
Provisional data: **HES**: MT, NL; **GOV**: IE (total), MT, UK (total); **BES**: BE
Data estimated: EU-27, EU-25, EU-15 (by DG Research); **HES**: NL, CH; **BES**: EE, UK
Head Count

Has this gender imbalance across broad economic sectors been leveling out over recent years? It appears that this has not really been the case. The study gives information on the rate at which the numbers of male and female researchers have been increasing (or decreasing) on an average annual basis between 2002 and 2006 in each of three economic sectors. "*In the higher education sector, which hosts a larger share of female than of male researchers, the compound annual growth rate in the number of female researchers has been stronger than that of men over the period 2002-2006 in most countries (26 out of 31). Only in 5 countries, the inverse holds true. These countries are the Czech Republic, Greece, the Netherlands, Latvia, and Sweden. However, the differences in growth rates are extremely modest in the former three countries. In Latvia, the compound annual growth rate over 2002-2006 of male researchers stood at 4.6% and that of female researchers at 3.6%. Only in Sweden has the gender difference in growth rates of male and female researchers been really sizable, the number of female researchers has indeed been decreasing over recent years at an average annual pace of -3.5%; whereas the number of male researchers has been slowly on the rise at a rate of 1.4%. These exceptions aside, in most countries, there seems to be some move towards a more gender-balanced research population in higher education. Throughout the EU-27 on average, the annual growth rate for women has been 4.8% compared with 2.0% for men. Finally, the level of the growth rates of both female and male researchers is extremely variable over the different countries, ranging from 22% for women and 20% for men in Romania to the extremely low level (negative even) we already mentioned for Sweden. The government sector puts forth a very similar pattern. A larger share of female than of male researchers is in this sector and women's presence has been strengthening over recent years in the majority of countries. On average in the EU-27, the number of female researchers has been growing at a pace of 5.4% per year compared with 2.3% for men. There are just four exceptions to this overall pattern. In Hungary and Portugal, the growth*

rate of male researchers is only marginally above that of women but in Latvia and Luxembourg, male researchers have been reinforcing their predominance in this sector over the period 2002-2006, at an annual rate of 19.8% in Latvia (compared with a 8.7% growth rate for female researchers) and 10.8% in Luxembourg (compared with 5.9% for women). Again, the cross-country distribution of growth rates is very wide ranging from 21.3% for female researchers in Iceland and -3.8% in Croatia and from 19.8% for male researchers in Latvia and -4.8% in Croatia. Finally, in the business enterprise sector, where the proportion of female researchers is generally lower than that of men, the compound annual growth rate of the number of female researchers has been stronger than that of men over the period 2002-2006 in roughly half of the countries (17 out of 33). In these countries, there thus seems to be some move towards greater equality in this sector. There is nevertheless a high level of cross-country disparity in the level at which this balancing out is taking place. For example, whereas in Lithuania the respective compound annual growth rates for female and male researchers were at 33.6% and 29.6% over the period 2002-2006, in Norway, the growth rate of female researchers was just less negative than that of male researchers (-1.1% and -2.3% respectively). In 13 countries, the inverse holds true thus pointing towards a widening over time of the gender imbalance in the research population of the private sector. These countries are Turkey, Poland, Hungary, France, Slovenia, the Czech Republic, Cyprus, Portugal, Germany, Bulgaria, Romania, Latvia and Slovakia. Finally, in Sweden, the UK and Croatia, male and female researchers have been growing at an equal pace." (She Figures 2009, EC, 2009b p. 23,).

Figure 8: Percentage of researchers who are women by sector in EU Member States, HC, 2000



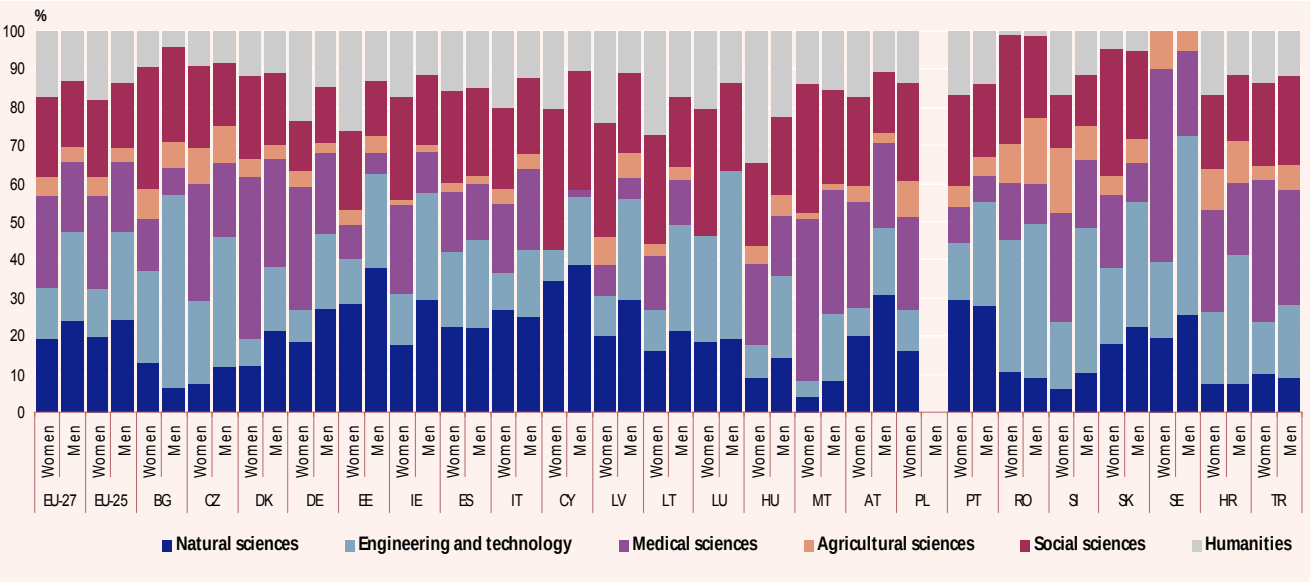
Source: She Figures 2003, p. 29 (EC, 2004); Eurostat, S&T statistics; DG Research, WiS database
Notes: (1) Exceptions to the reference year: IT (HES), LU (HES & GOV), SE (HES): 2001; DK (BES), DE (BES), EL, ES (BES), IE (GOV, BES), IT (GOV), PT, SE (GOV): 1999; AT: 1998
(2)FTE as exception to HC: SE (GOVonly); IE (GOV & BES only)
(3)EU-15 estimate excludes BE & NL forGOV and BE, LU, NL, SE & UK for BES
(4)Data provisional
(5)Data not official

2.1.2. Women employed in research across fields of science

The distribution of male and female researchers in the higher education sector across different fields of science in 2006 (Figure 9) indicates that female researchers are concentrated in medical sciences (24% on average in the EU-27). It is the contrary for agriculture where they constitute 5.2% on average in the EU-27. The widest gender gap is not surprisingly observed in engineering. Again there are many cross-country differences in the relative importance of each of the fields of science. *"Whereas just 4% of female*

researchers are in the natural sciences in Malta, 35% are in Cyprus. In engineering and technology, the low proportions of female researchers observed in Malta (4.5%), Austria (7.3%), Denmark (7.4%) and Cyprus (7.6%) contrast sharply with the much higher shares of women in Romania (35%), Luxembourg (28%) and Bulgaria (24%). Such contrasting national patterns characterise the medical sciences also with particularly high shares of female researchers in medicine in Sweden (51%), Malta (42%), and Denmark (42%) and particularly low shares in Estonia (9%), Latvia (8%) and Portugal (9%). The share of female researchers in the humanities is minimal at 5% in Slovakia whereas it peaks at 35% in Hungary" (She Figures 2009, EC, 2009b, p. 42). In social sciences that one observes few cross-country variations in the proportions of researchers.

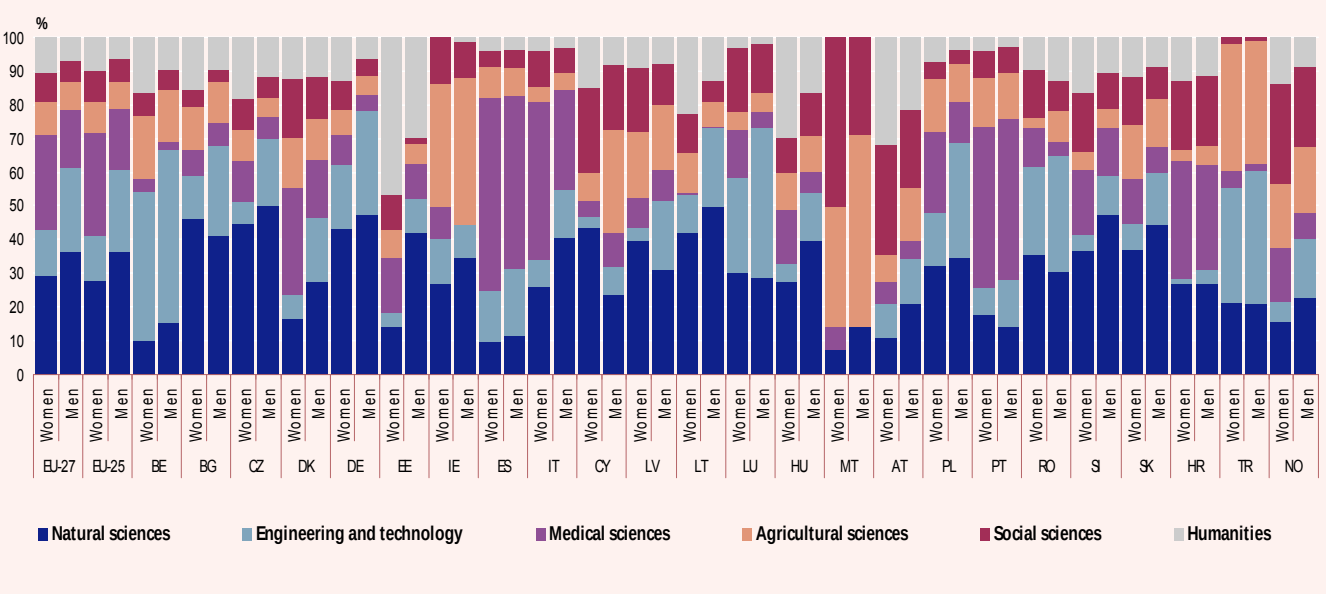
Figure 9: Distribution of researchers in the Higher Education Sector (HES) across fields of science, 2006



Source: She Figures, 2009, p. 55, (EC, 2009b) on the basis of the S&T statistics (Eurostat)
Exceptions to the reference year: CZ, EE, MT, SK: 2007; LU, PT, SE: 2005
Data unavailable: BE, EL, FR, NL, FI, UK, IS, NO, CH, IL; SE: Humanities and Social sciences (2005), PL (men)
Provisional data: MT (2007)
Data estimated: EU-27, EU-25 (by DG Research)
Head count

Concerning the government sector (Figure 10), female researchers are best represented in the medical sciences (like in the HES sector) and also in the natural sciences (both 29% on average in the EU-27). In medicine the share of female researchers is 12 percentage points higher than that of male researchers In natural sciences, there is a greater proportion of male researchers (37%). Again, a very wide gender gap is observable among the research population in the field of engineering. Engineering hosts only 14% of women researchers (the gap stood at 11% in 2006 throughout the EU-27). As in higher education, female researchers are the least present in agriculture and in the social sciences (9% on average in the EU-27). Again, cross-country differences are observable: "*Whereas just 7% of female researchers are in the natural sciences in Malta, 46% are in Bulgaria. In engineering and technology, the low proportions of female researchers observed in Estonia (5%), Slovenia (5%), Latvia (4%), Cyprus (3%) and Croatia (1%) contrast sharply with the much higher shares of women in Belgium (44%), Turkey (34%), Luxembourg (28%), and Romania (26%). Such contrasting national patterns characterise the medical sciences also with particularly high shares of female researchers in medicine in Spain (58%) and Portugal (48%) and particularly low shares in Lithuania (1%), Belgium (3%), Cyprus (5%) and Turkey (5%). The share of female researchers in the humanities is lowest at 3% in Luxembourg whereas it peaks at 46% in Estonia. Whereas there was the least cross-country variation in the proportions of researchers in the social sciences in the higher education sector, in the government sector, this fails to hold true. Indeed, the proportion of female researchers ranges from 2% in Turkey to 50% in Malta"* (She Figures 2009, [E.C, 2009b] p. 44).

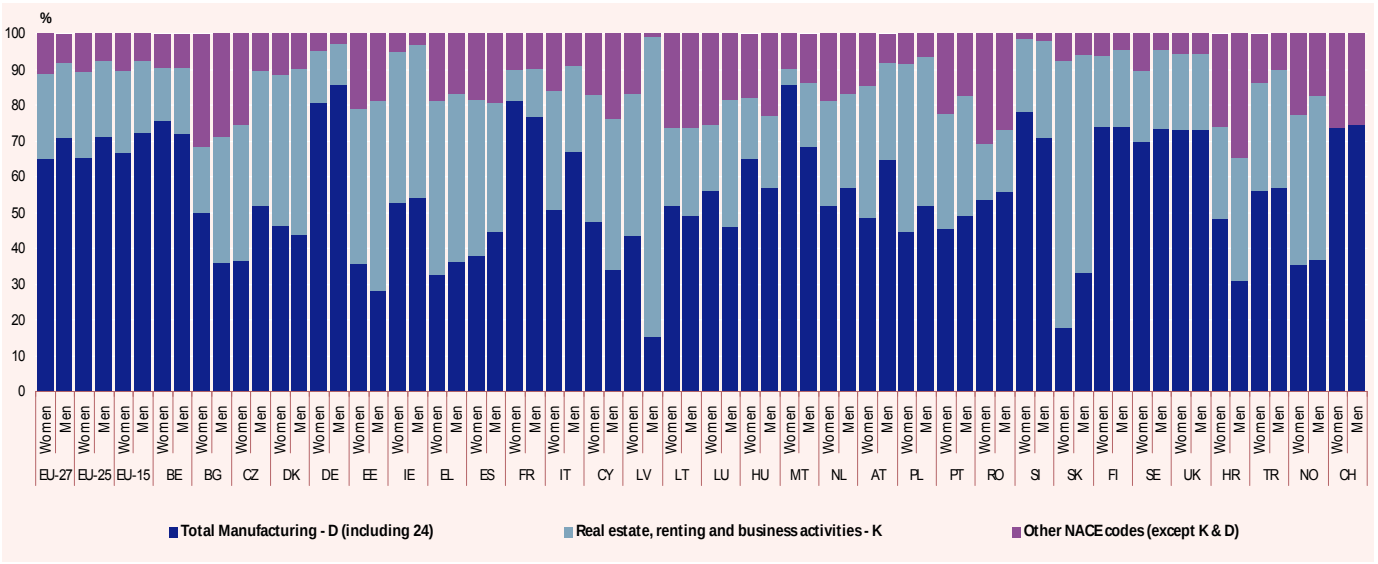
Figure 10: Distribution of researchers in the Government Sector (GOV) across fields of science, 2006



Source: She Figures, 2009, p. 58, (EC, 2009b) on the basis of the S&T statistics (Eurostat)
Exceptions to the reference year: CZ, EE, IE, MT, SK: 2007; BE, LU, PT, NO: 2005; TR: 2004
Data unavailable: EL, FR, NL, FI, UK, CH, IL, SE, IS
Provisional data: IE (2007), PT (2007)
Data estimated: EU-27, EU-25 (by DG Research)
Head count

Finally, regarding the business enterprise sector, researchers are distributed across different economic activities (Figure 11). Two sectors of activity are studied: manufacturing; and real estate, renting and business activities. Research activities are mainly conducted within the manufacture and real estate sectors. These two economic sectors can be compared with all other economic activities taken together. In most countries, the highest shares of both male and female researchers are in manufacturing. The share of women in this sector stood at 65% and that of men at 71% in 2006 (for the EU-27). However, for the Czech Republic, Estonia, Greece, Spain, Poland, Slovakia, and Norway, the share of female researchers is highest in real estate, renting and business activities rather than in manufacturing. The share of male researchers is also highest in this sector of economic activity in Denmark, Estonia, Greece, Cyprus, Latvia, Slovakia and Norway. Moreover, "*If one focuses on pharmaceuticals as a subgroup of the overall manufacturing sector, the share of female researchers at the level of the EU-27 increases to 38.5% from 17.3% in the broad sector of manufacturing. This illustrates that women are relatively better represented in the manufacture of pharmaceuticals than in that of other products"* (She Figures 2009, [EC, 2009b p.46]). Besides manufacturing, the share of female researchers in real estate, renting and business activities stood at 20.5% at the level of the EU-27 in 2006. Finally, the other sectors of economic activity host only 11% of female researchers and 8% of male researchers (in the EU-27 on average).

Figure 11: Distribution of researchers across economic activities (NACE) in the Business Enterprise Sector (BES), 2006



Source: She Figures, 2009, p.61, (EC, 2009b) on the basis of the S&T statistics (Eurostat)
Exceptions to the reference year: CZ: 2007; BG, DK, DE, EE, IE, EL, IT, NL, PT, SK, UK, NO: 2005; FR, CH: 2004, LU, SE: 2003
Data unavailable: IS, IL; CH: Real estate, renting and business activities - K
Provisional value: BE (2006)
Data estimated: EU-27, EU-25, EU-15 (by DG Research); UK (2005), LU (2003)
Head count

Table 3 presents the values of the dissimilarity index (for 2006 and for some countries for 1999 also) in the different countries for two sectors: higher education and government. Seven fields of occupations are considered: natural sciences, engineering and technology, the medical and health sciences, agricultural sciences, the social sciences, the humanities or in any other field of science. At the EU-27 level, the dissimilarity index stood at 0.14 in higher education compared with 0.18 in the government sector. There is thus less gender segregation across occupations in higher education (since the value is closer to zero) than in the public enterprises. In higher education, the level of segregation is the highest in Latvia (0.25), Slovenia (0.25), Ireland (0.26), Bulgaria (0.27), and Sweden (0.31). The lower index is observable in Spain (0.03). In the government sector, the countries with the lower gender balanced distribution of researchers across the different fields of science are Malta (0.32), Cyprus (0.33) and Estonia (0.34). Again Spain shows one of the lowest levels of gender segregation (0.07) as well as Portugal (0.06).

Table 3: Dissimilarity index for researchers in Higher Education Sector (HES) and Government Sector (GOV), 2006

	Dissimilarity Index HES (DI)		Dissimilarity Index GOV (DI)
	2006	1999	2006
EU-27	0,14	:	0,18
EU-25	0,15	:	0,19
EU-15	0,14	:	0,20
BE	:	:	0,12
BG	0,27	:	0,14
CZ	0,17	:	0,19
DK	0,19	0:20	0,23
DE	0,21	0,23	0,16
EE	0,23	:	0,34
IE	0,26	:	0,16
ES	0,03	:	0,07
FR	:	0,12	:
IT	0,11	0,18	0,21
NL	:	0,18	:
CY	0,16	:	0,33
LV	0,25	:	0,17
LT	0,23	:	0,20
LU	0,17	:	0,16
HU	0,19	:	0,23
MT	0,20	:	0,32
AT	0,21	0,21	0,20
PL	:	:	0,21
PT	0,12	0,12	0,06
RO	0,13	:	0,17
SI	0,25	:	0,18
SK	0,19	:	0,15
UK	:	0,17	:
FI	:	0,20	:
SE	0,31	0,23	0,00
HR	0,15	:	0,05
TR	0,10	:	0,05
NO	:	:	0,19

Source: She Figures, 2003, (EC, 2004) She Figures, 2009 p.64, (EC, 2009b) on the basis of the S&T statistics (Eurostat)
Exceptions to the reference year: **HES**: CZ, EE, MT, SK: 2007; LU, PT, SE: 2005; **GOV**: CZ, EE, IE, MT, SK: 2007; BE, LU, PT, NO: 2005; TR: 2004; SE: 2003
Data unavailable: EL, FR, NL, FI, UK, IS, CH, IL, BE (HES), PL (HES), NO (HES)
Provisional data: **HES**: MT (2007); **GOV**: IE (2007), MT (2007)
Data estimated: EU-27, EU-25, EU-15 (by DG Research)
':' : not avalaible
Head count

Data can be compared between 1999 and 2006 for 6 countries only (Table 3). For 3 of these 6 countries, the index has increased (Denmark, Germany and Italy). It has decreased in Sweden and it has remained stable in Austria and Portugal.

The values of the ID index for researchers in all sectors confounded are lower than those calculated for the labour market as a whole (cfr. Section 1.4). We investigated the differences between segregation in the total workforce (male and female workers) and in research (male and female researchers). Table 4 presents the values of the ID index measuring horizontal segregation (across sectors of economic activity –Nace.Rev.1, 1-digit) for 3 populations: the total workforce, the population of researchers and the population of the most highly qualified researchers (with a Ph.D. degree)[1] for all members of the EU-27 for

[1] This category includes highly educated researchers working in ISCO 210-400 occupations.

2007. Horizontal segregation among researchers should be understood as a different distribution of male and female researchers over the different sectors of economic activity. The table shows that horizontal segregation in the population of researchers is lowest in Greece, Spain, Luxembourg and Romania and highest in Ireland and Denmark. In 12 countries, the ID index is lower among researchers than in the labour market as a whole and it drops even further when one compares total researchers with the subsample of the most highly qualified researchers. 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 researchers 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, although higher for researchers than for the total workforce, is lower amongst the most highly qualified researchers (ISCED 6) than amongst researchers of all levels of education (ISCED 5A and 5B). In Cyprus and Estonia, sectoral dissimilarity is highest between the most highly qualified male and female researchers. Finally, in Hungary, Bulgaria and Latvia, the index is smaller among researchers than in the total workforce but it rises between researchers and the subcategory of the most highly qualified researchers.

Table 4: Horizontal segregation (ID-index): comparison of researchers with the total workforce, 2007

	Total population	Researchers (ISCED 5A, 5B, 6)	Researchers with a Ph.D. (ISCED6)
GR	0,28	0,23	0,16
ES	0,39	0,24	0,13
LU	0,32	0,24	0,20
RO	0,20	0,24	0,23
CY	0,30	0,26	0,56
HU	0,46	0,28	0,41
BG	0,29	0,29	0,32
EE	0,36	0,29	0,50
FR	0,34	0,29	0,19
LV	0,38	0,29	0,32
PL	0,26	0,30	0,22
PT	0,40	0,30	0,12
SI	0,28	0,30	0,15
AT	0,41	0,31	0,25
BE	0,28	0,32	0,14
NL	0,41	0,32	0,29
DE	0,31	0,33	0,30
CZ	0,31	0,34	0,30
FI	0,39	0,34	0,25
IT	0,27	0,34	0,10
SK	0,32	0,34	0,52
LT	0,32	0,35	0,17
SE	0,41	0,35	0,16
UK	0,37	0,36	0,14
NO	0,40	0,37	0,14
IE	0,42	0,40	0,11
DK	0,40	0,42	0,19

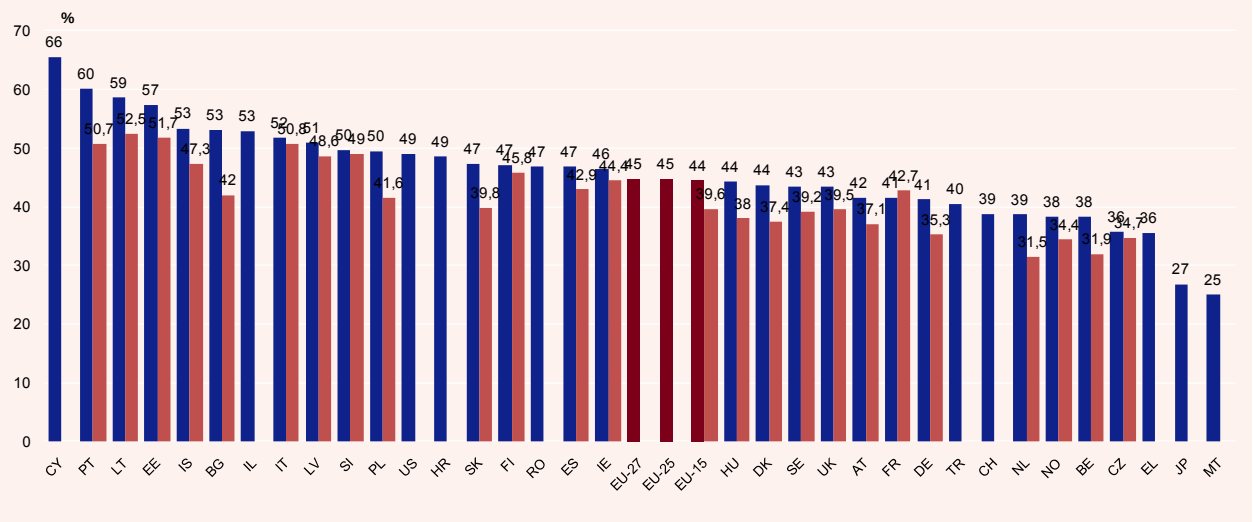
Source: LFS 2007, own calculations
Note: the figures in the last column relative to researchers who hold a Ph.D. degree should be interpreted with caution due to small sample sizes

2.1.3. Segregation in higher education

This section is devoted to segregation in higher education. Decisions with respect to the field of study could lead to horizontal segregation between women and men in the labour market.

Figure 12 on the proportion of female PhD graduates for 2006, shows that on average in the EU-27, 45% of all PhD graduates are women. The countries situated at the top of the rank are Cyprus (66%), Portugal (60%), Lithuania (59%) and Estonia (57%). Eleven countries have 50% or more PhD graduates. At the end of the rank, the countries with the lower scores are Japan and Malta, with respectively 27% and 25%. A notable evolution has occurred in the proportion of female PhDs between 2001 and 2006: the EU-15 average rose from 39.6% in 2001 to 44% in 2006. In general, with the exception of France, the percentage of female PhDs has grown in all countries for which data are available between 2001 and 2006. Marked changes are observed in Portugal (from 50.7% to 60% over the period) as well as Bulgaria (from 42% to 53%) and Poland (from 41.6% to 50%). The proportion rose from 42.9% to 47% in Spain; from 37.4% to 44% in Denmark; from 37.1% to 42% in Austria; from 31.9% to 38% in Belgium; from 31.5% to 39% in the Netherlands; from 52.5% to 59% in Lithuania; from 51.7% to 57% in Estonia; from 47.3% to 53% in Israel; from 39.8% to 47% in Slovakia; and from 38% to 44% in Hungary.

Figure 12: Proportion of female PhD (ISCED 6) graduates, 2006

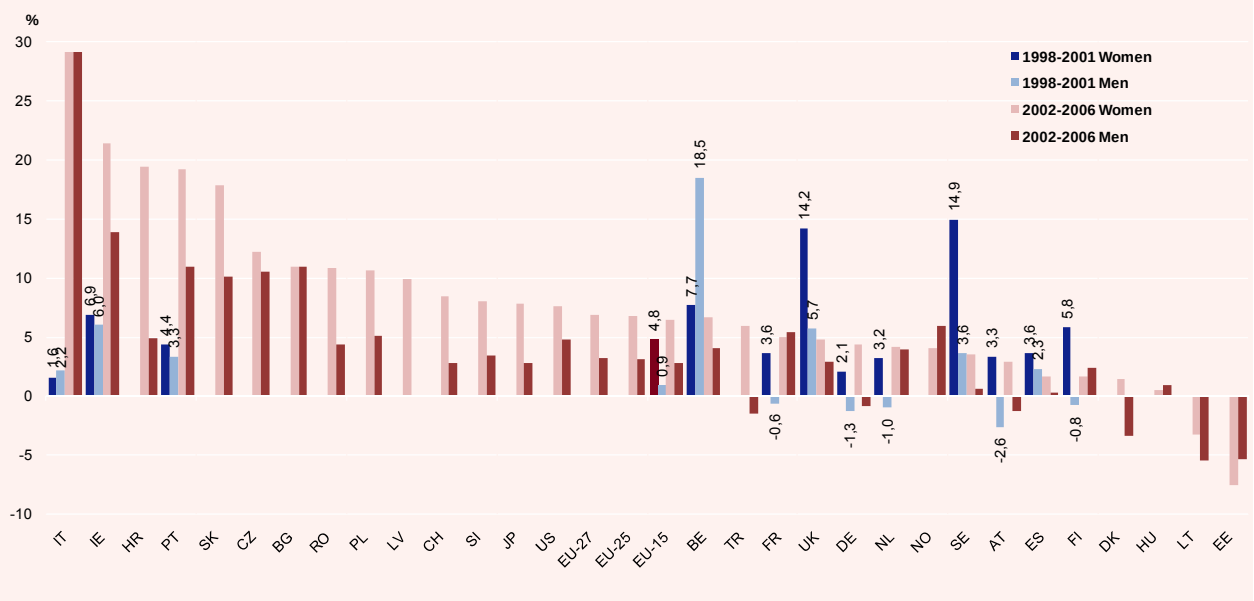


Source: She Figures, 2003, p.23 (EC, 2004) and She Figures 2009, p. 49 (EC., 2009b), , on the basis of the Education Statistics (Eurostat), Central Bureau of Statistics (Israel), Norwegian Institute for Studies in Innovation, Research and Education
Exceptions to the reference year: EL, IT: 2005
Data unavailable: LU
Data estimated: EU-27 (by Eurostat), EU-25, EU-15 (by DG Research)
Countries with small numbers of female PhD graduates: CY (19), IS (8), MT (1)
Most tertiary students study abroad and are not included: CY

From Figure 13 which yields the compound annual growth rate of PhD graduates by sex, one can observe that with the exception of Italy, France, Norway, Finland, Hungary, Bulgaria and Estonia, women's under-representation amongst PhD graduates has been on the decline in recent years. In the majority of countries, the compound annual growth rate of female PhD graduates exceeds that of men over the period. On average in the EU-27, the number of female PhD graduates increased at a rate of 6.8% per year compared with 3.2% for male PhD graduates. The difference between women and men's rates is the highest in Croatia, Portugal, Slovakia, Romania, Denmark and Switzerland. These figures clearly prove that women are catching up with men. This increase of women's educational level will probably result in women being at least equally or even more present than men at the PhD level in the near future.

On the basis of She Figures 2003, we can compare the compound annual growth rate of PhD graduates for the period 1998-2001 to the period 2002-2006. During the first period the compound annual growth rate was 4.8 for women and 2.4 for men. During the second period these numbers were 6.5 and 2.9 respectively. The compound annual growth rate has significantly risen over time.

Figure 13: Compound annual growth rate of PhD (ISCED 6) graduates by sex, 1998-2001 and 2002-2006



Source: She Figures 2003, p.23 (EC, 2004) and She Figures 2009, p. 50 (EC, 2009b), on the basis of the Education Statistics (Eurostat), Norwegian Institute for Studies in Innovation, Research and Education
Exceptions to the reference year(s): FR, RO, HR: 2003-2006; IT: 2002-2005, NO: 2001-2005, BE: 2000-2001; DK: 1999-2000; FR, IT, FI: 1998-2000
EU-15 estimate excludes EL, LU and is calculated for 3-year period.
Data unavailable: LU, IL, EL (not shown as only two consecutive years are available resulting in extreme values)
Data estimated: EU-27, EU-25, EU-15 (by DG Research)
Compound annual growth rates not presented for countries with less than 30 graduates: CY, LV (men), MT, IS

2.1.4. Segregation in education: fields of science

Despite the rise in women's level of education and in their proportion among Ph. D. graduates, there remains a significant degree of segregation in terms of fields of study.

When studying segregation it is necessary to look at the gendered repartition of PhD graduates across fields of study. Table 5 shows the proportion of female Ph.D. graduates by broad field of study in 2006. It shows that in 2006, on average throughout the EU-27, women PhD holders dominate in the field of education: 64% of the PhD graduates in education are women. They also constitute a majority in the field of health and welfare (54%), of humanities and art (52%), and of agriculture and veterinary (51%). In social sciences business and law, their proportion is 47%. This proportion falls to 41% for science, mathematics and computing and drops even lower to 25% for engineering, manufacturing and construction! However, this situation strongly varies among countries: *"The feminisation of the field of education is most pronounced in Portugal, Slovenia and Finland where only one in four PhD graduates in this field is a man. Note that although education appears to be 100% feminised in Estonia, Cyprus, and Iceland, this is probably due to very small sample sizes of PhD graduates in this field in these countries. When comparing the degree of masculinisation of engineering, manufacturing and construction cross-nationally, it appears that less than one in five PhD holders in this field is a woman in Germany (14%), Switzerland (19%) and Japan (11%). On the contrary, in Estonia, engineering appears to be a women's field with 59% of female PhD graduates. Estonia is clearly an exceptional case. Nevertheless, the smallest relative degrees of masculinisation of this field (>35% of female PhDs) are observed in Italy, Portugal, Latvia, Lithuania, Croatia, and Turkey […] Compared with the EU-27 average (7.9%), the proportion of female PhD graduates in engineering, manufacturing, and construction is much lower in many countries, the minimum is observed in Germany (2.9%). On the contrary, in Sweden up to 20% of female PhDs are in this field. In contrast with these relatively low shares of female PhDs in engineering, more than 30% of male PhDs are in this field in Sweden, Finland, Denmark, Bulgaria, the Czech Republic, and Slovenia. There is even more cross-country disparity in the proportion of female PhDs in health and welfare. Although the EU-27 average stood at 21.5%, it drops as low as 2.6% in France and mounts as high as 41% in the Netherlands. The share of male PhDs in the field of health and welfare is generally well below that of women. Nevertheless it should be noted that in Germany and Japan more than one quarter of male PhDs (26.8% and 30.2% respectively) are in this field. There is usually more gender balance in science, mathematics and computing and in the social sciences, business and law. Across the countries, the share of female PhDs in science, mathematics and computing ranges from 9.3% in Latvia to 43.9% in France (63.2% in Cyprus are probably overestimated due to the small numbers of female PhDs in some of the study fields). The share of male PhDs in this field varies between 6.4% in Romania and 53% in France. A few countries form exceptions to the overall picture of more balance between the proportions of male and female PhDs in the social sciences, business and law. In 5 countries is the proportion of female PhDs in this field substantially larger than that of men. Indeed, the gender gap is above 5% in France, Lithuania, Finland, the UK, and the US and it reaches as high as 10.1% in Austria. For the humanities and arts, the exceptional cases of Slovakia, Belgium, Lithuania Turkey, the US, and to a lesser extent Croatia deserve special attention. In these countries the general trend is reversed and a higher share of male PhD graduates than of female PhDs are in this field of study. Finally, only small shares of both male and female PhDs are in agricultural and veterinary sciences and in education". (She Figures 2009, [EC, 2009b] pp. 40-41).*

On the basis of the results from She Figures 2003, (EC, 2004) one can compare the proportion of female Ph.D. graduates between 2001 and 2006 in a number of countries (Table 5). Between the two years, there are differences in the evolution of the number of female PhD graduates by broad field of study. The most important finding is that women's share among Ph.D. graduates has increased in all fields of study. The disciplines where the rise of women has been most marked are Education (increase by 8.6 percentage points between 2001 and 2006), followed by Social science, Business and Law (increase by 7.7 percentage points). In Engineering, Manufacturing and Construction, their proportion has increased by 4.4 percentage points and in Science, Mathematics and Computing, by 4.3 percentage points.

Table 5: Proportion of female PhD (ISCED 6) graduates by broad field of study, 2001 and 2006

	Education		Humanities & arts		Social sciences Business & Law		Science mathematics & computing		Engineering, manufacturing & construction		Agriculture & veterinary		Health & welfare	
	2001	2006	2001	2006	2001	2006	2001	2006	2001	2006	2001	2006	2001	2006
EU-27		64		52		47		41		25		51		54
EU-25		64		52		47		41		25		52		54
EU-15	55	64	49	52	39	47	36	40	21	25	47	52	49	54
BE	55	50	31	32	35	38	34	40	15	26	31	35	40	49
BE		52		68		58		56		33		54		56
CZ		62		42		41		39		20		41		43
DK			51	50	42	46	33	34	24	25	47	61	48	63
DE	42	53	45	51	32	37	27	35	12	14	53	60	46	51
EE		100		77		39		47		59		100		68
IE	50	64	54	52	49	57	43	45	22	26	37	61	60	57
EL		47		52		33		31		25		27		86
ES	54	57	45	48	44	46	45	48	23	25	33	44	49	54
FR	50	59	57	54	42	48	39	37	27	27	57	65	57	46
IT		68	58	59	46	52	48	52	34	36	56	55	66	62
CY		100		67		29		75						
LV		67		69		54		36		43		50		48
LT				50		68		63		40		75		69
HU		61		49		52		39		29		45		39
MT		0						100		0				0
NL			32	40	37	44	26	29	14	20	33	38	42	51
AT	62	64	51	45	39	49	36	38	13	21	51	55	72	60
PL				54		51		57		24		54		54
PT	66	76	64	67	46	60	50	55	39	39	56	55	65	69
RO		30		47		47		62		35		46		49
SI		75		66		54		60		22		57		47
SK		54		46		52		44		33		38		65
FI	72	75	46	55	51	55	37	39	21	24	39	51	63	65
SE	66	58	44	54	41	42	33	37	24	29	48	46	53	62
UK	55	59	46	48	40	51	39	38	19	22	40	48	52	55
HR		64		48		54		58		38		42		44
TR		41		35		38		38		36		38		55
IS		100		0		0		60		100				40
NO		65		42		42		31		23		52		52
CH		67		49		38		33		19		68		46
JP		45		51		35		22		11		26		29
US		65		46		57		38		21		41		73

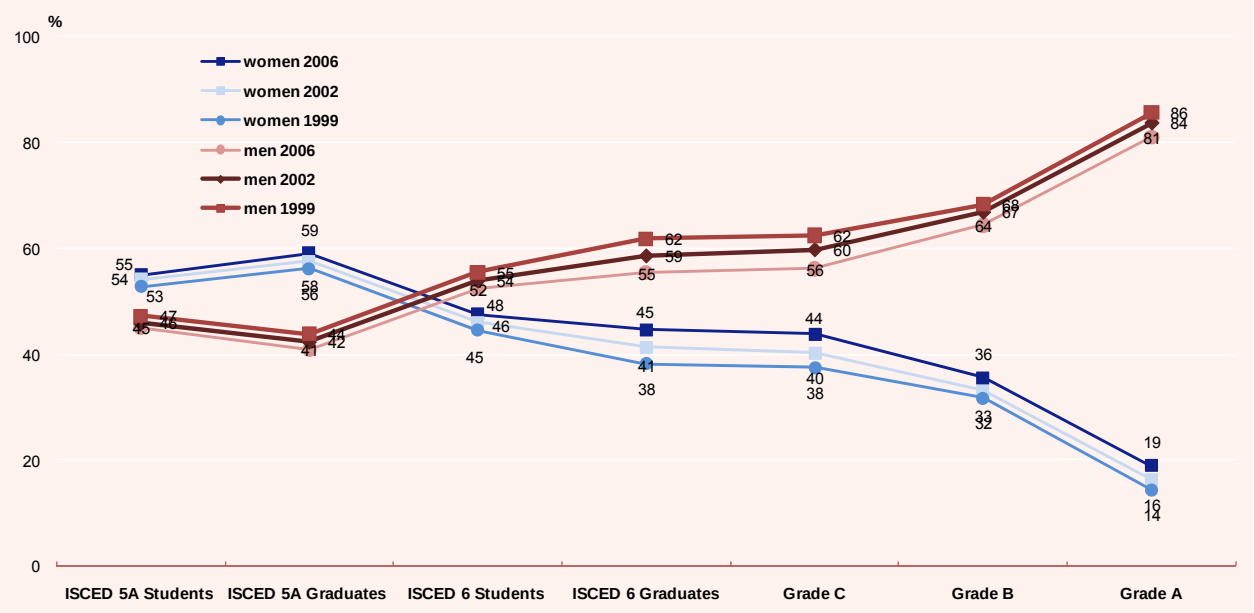
Source: She Figures 2003, p.43 (EC., 2004) and She Figures 2009, p. 51, (EC., 2009b), , on the basis of the S&T statistics (Eurostat)
Exceptions to the reference year: IT: 2005, EL: 2005; DK, FR, IT, FI: 2000
Humanities and arts includes education in DK in 2001
EU-15: 2001 estimate excludes EL, LU.
Data unavailable: IL, LU
Data estimated: EU-27, EU-25 (by Eurostat), EU-15 (by DG Research)
':' : not avalaible; '-': not applicable
Most tertiary students study abroad and are not included: CY

2.2. Vertical segregation

Available data on vertical segregation concerns mostly the academic sector. The academic career of women remains strongly marked by vertical segregation. In general, the proportion of women is clearly declines the higher up the academic ladder. This phenomenon is commonly illustrated by the scissor's diagramme that is built on cross-sectional data: "*the diagramme shows the proportion of men and women at each stage of the academic career in a given year and compares them to the proportion that one would expect to find given the numbers of men and women undergraduates in prior years, based on the assumption that men and women were equally likely to stay in the system and to progress through at equal rates*" (ETAN report 2000, p.13). In the first two levels of university education (ISCED 5A students and graduates), the proportion of women outnumbers those of men. Indeed the feminisation of the student population is one of the most striking elements of the evolution over the last 30 years in most European countries. The situation changes when reaching the "ISCED 6 student" level (students in programmes leading to the award of an advanced research qualification such as the PhD that are devoted to advanced study and original research) where the proportion of women is 48% and those of men 52%. Then the proportion of women drop back to 45% for the PhD graduates (55% for men) and the gender gap widens. The PhD degree often constitutes a necessary level to enter the academic career so the attrition of women at this level will have a knock-on effect on their relative representation at the first stage of the academic career. Furthermore, women represent only 44% of grade C academic staff (56% for men), 36% of grade B academic staff (64% for men) and 18% of grade A academic staff (82% for men). The grade C academic staff is the first grade/post into which a newly qualified PhD graduate would normally be recruited. The grade B academic staff represents researchers working in positions not as senior as top positions but more senior than newly qualified PhD holders. Finally, the grade A academic staff constitutes the single highest grade/post at which research is normally conducted. The figures illustrate the workings of a "sticky floor", "*a metaphor to point towards the difficulties graduated women face when trying to slip into the first levels of the academic career*" (p. 66). This figure clearly bears witness to the existence of a glass ceiling composed of hard to identify obstacles that hold women back from accessing the highest positions in the hierarchy.

Figure 14 enables one to evaluate the evolution of vertical segregation from 1999 to 2006. It shows an improvement in women's relative position. At the level of ISCED5A graduates, the increase in the proportion of women between 1999 and 2006 was of 3 percentage points (at these low levels, the proportion of women is higher than that of men). At the level of ISCED6 students, women's proportion also rose by 3 percentage points while for ISCED6 graduates there was an increase by 7 percentage points between 1999 and 2006. The proportion of women among Grade C increased by 6 points over the period while there was an increase by only 4 points for Grade B and 5 points for Grade A. The increase in the proportion of women was higher among ISCED6 graduates and Grade C and it diminishes among higher hierarchical levels. The increase in the proportion of women is lower at higher hierarchical levels. This illustrates a higher resistance to the integration of women in higher levels (especially Grade A). It is also worth noting that these improvements appear to be very slow and it is obvious that without proactive policies, it will take decades to close the gender gap and to reach a higher degree of gender equality.

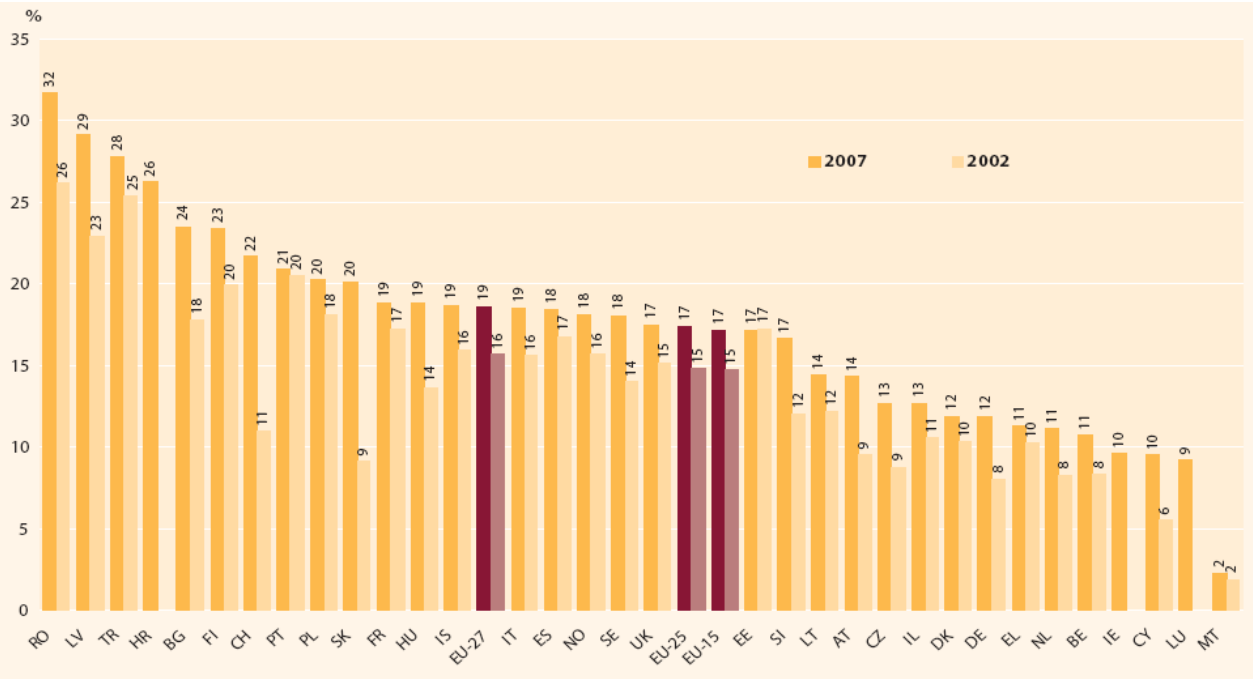
Figure 14: Proportions of men and women in a typical academic career, students and academic staff, EU-27, 1999, 2002, 2006



Source: She Figures 2003, p. 55 (EC, 2004) She Figures 2009, p.73 (EC, 2009b),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 into advanced research programmes & professions with high skills requirements.
ISCED 6: Tertiary programmes which lead to an advanced research qualification (PhD).

Figure 15 presents the evolution of the proportion of women in Grade A academic position for the years 2002-2007 and by country. Several countries show very important evolutions of their proportion of women among Grade A such as Slovakia and Switzerland. In some other, the percentage remains almost stagnant over the period: Portugal, Estonia and Greece.

Figure 15: Proportion of women in grade A academic positions, 2002/2007

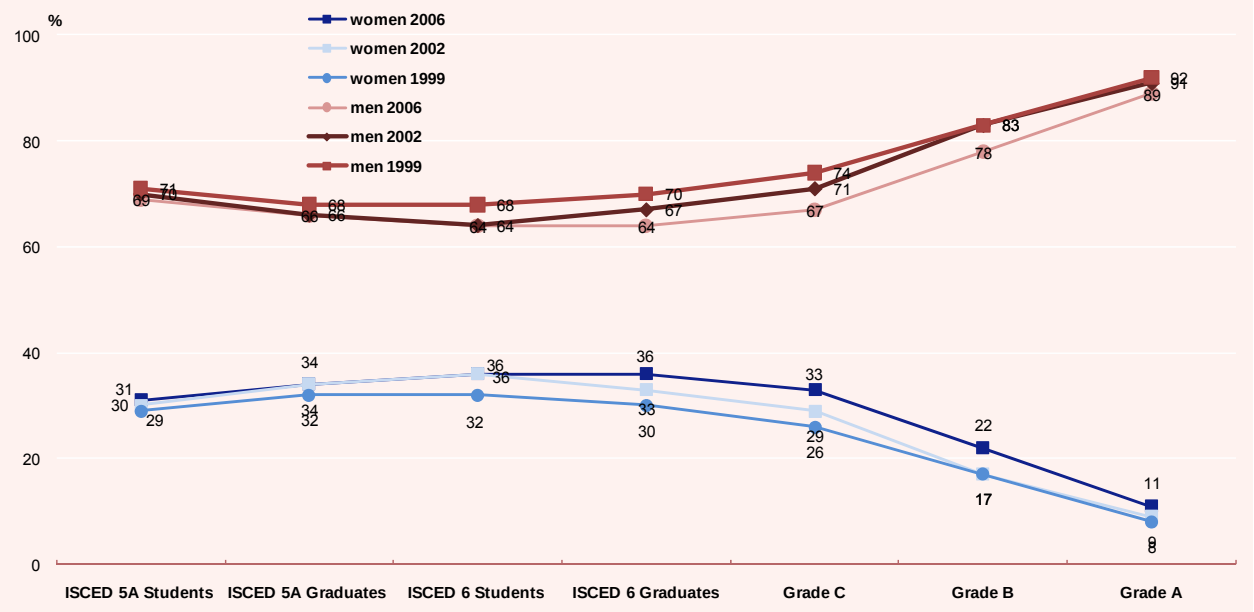


Source: She Figures 2009, p. 77 (EC, 2009b),; WiS database (DG Research); Higher Education Authority for Ireland
Exceptions to the reference year (s): 2007 HR: 2008; UK: 2007/2006; DK, FR, CY, LU, AT, IL: 2006; EE, MT: 2004; PT: 2003; IE: 2002-2003; EL: 2000; 2002 NO, UK, NL: 2003; IL: 2001; EL: 1999
Data unavailable: HR, LU, IE: 2002
Break in series: CZ (2005)
Provisional data: ES
Data estimated: EU-27, EU-25, EU-15 (by DG Research), SI
Head count
NO: before 2007 biannual data
Data for Ireland on Grade A professors does not include the Institutes of Technology

The previous figures document vertical segregation in the academic world (in the EU-27). The scissor diagram (Figure 16) concentrates only on the field of science and engineering. The picture differs considerably and shows a more alarming degree of women's under-representation. This field is particularly unattractive to girls as only 31% chose this field of science in 2006. This is particularly problematic at the earlier stages of the academic career since the proportion of women increases throughout the first hierarchical echelons to reach 36% at the levels of PhD students and graduates. For the other stages of an academic career, science and engineering shows the same patterns as in general over all fields of study.

The most notable evolution between 1999 and 2006 concerns the proportion of women at Grade C (increase by 7 percentage points over the period). However, for ISCED5A and at Grade A, women's proportion has increased by just 2-3 percentage points over this period. It shows that the evolution amongst the higher and lower levels of the scale are relatively low, even lower than for the evolution in all disciplines. The evolution for ISCED6 (students), ISCED6 (graduates) and Grade B are respectively 4, 6 and 5 percentage points.

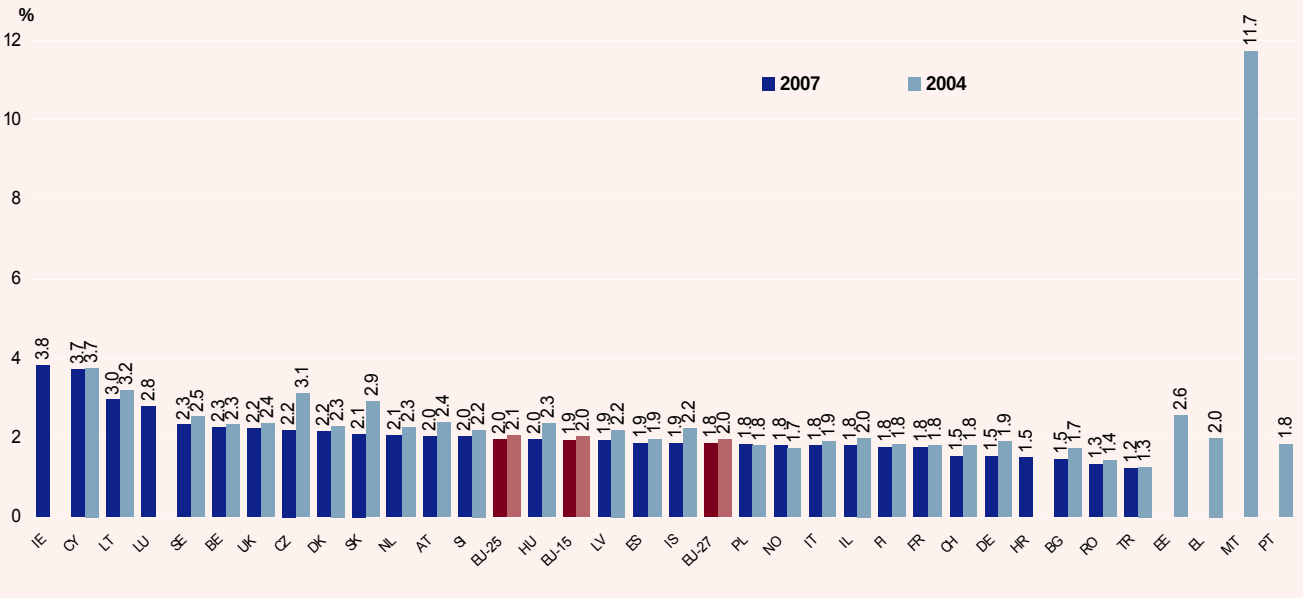
Figure 16: Proportions of men and women in a typical academic career in science and engineering, students and academic staff, EU-27, 1999, 2002, 2006



Source: She Figures 2003, p. 56 (EC, 2004) and She Figures 2009, p.74 (EC, 2009b) , on the basis of the Education Statistics (Eurostat); WiS database (DG Research)
Exceptions to the reference year(s): **ISCED 6 students 2002**: RO (men 2003), SI (men 2005); **WiS 2006**: ES (2007), MT (2004), PT (2003), SI (2007), SK (2007), FI (2007); 2002: IE (2004), FR (2000), LT (2005), NL (2003), UK (2003);
Data unavailable: **ISCED 6 students 2002**: DE, FR, LU, NL, SI (Women); **WiS 2006**: BG, EE, EL, FR, LV, LU, HU, RO, IE (Grade A); 2002: BG, EE, EL, ES, LV, LU, HU, RO, IE (Grade A)
Break in series: CZ (2005)
Provisional data: ES
Data estimated: EU-27 (by DG Research) for WiS, ISCED 6 students, SI
Head count (Grades A, B, C)
NO: before 2007 biannual data

The glass ceiling index (GCI) illustrates the difficulties women have in getting access to the highest levels of the hierarchy and measures their relative probability, as compared with men, of reaching a top position. The GCI "*compares the proportion of women in grade A positions (equivalent to Full Professors in most countries) to the proportion of women in academia (grade A, B, and C), indicating the opportunity, or lack of, for women to move up the hierarchical ladder in their profession. The value runs from 0 to infinity. A GCI of 1 indicates that there is no difference between women and men being promoted. A score of less than 1 means that women are over-represented at grade A level and a GCI score of more than 1 points towards a glass ceiling effect as women are under-represented in grade A positions. In other words, the interpretation of the GCI is that the higher the value, the thicker the glass ceiling and the more difficult it is for women to move into a higher position."* (She Figures 2009, [EC, 2009b]) p. 68). On average for the EU-27, the GCI stands at 1.8 (Figure 17). No country presents a GCI equal or below 1. Its value ranges from 11.7 in Malta to 1.3 in Romania. The index is the highest in Ireland, Cyprus, Lithuania, Luxembourg, Sweden and Belgium. The case of Malta is extreme in that it is the only country where so few female academics get into grade A positions. This can at least partly be explained by the fact that there is only one university in Malta. Between 2004 and 2007, the index has decreased or remained stable in all countries.

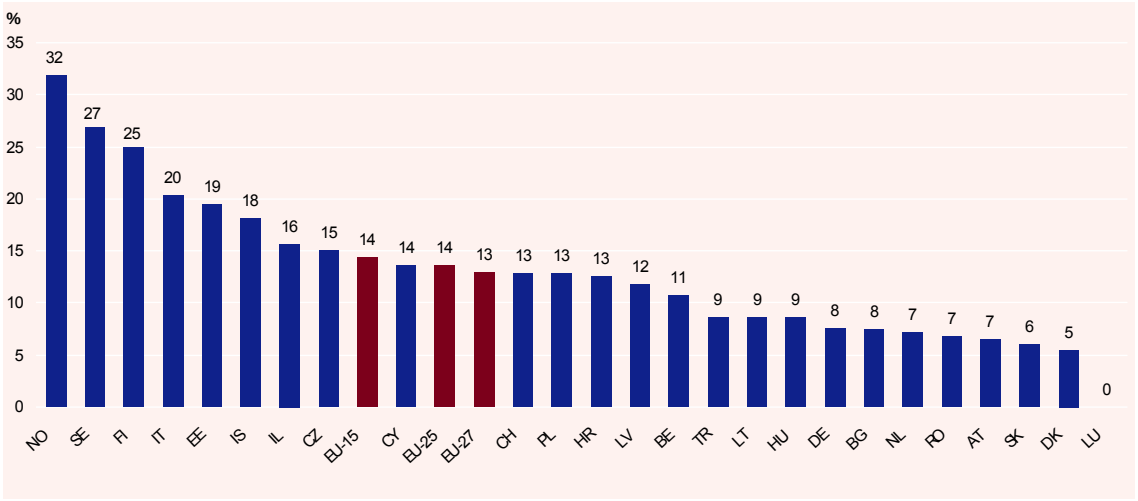
Figure 17: Glass Ceiling Index, 2004/2007



Source: She Figure, 2009, p.78 (EC, 2009b) on the basis of the WiS database (DG Research); Higher Education Authority for Ireland (Grade A)
Exceptions to the reference year (s): **2007** HR: 2008; UK: 2007/2006; DK, IE (except for grade A: 2002-2003), FR, CY, LU, AT, IL: 2006; **2004** PT, NO: 2003; IL: 2001; EL: 2000
Data unavailable: **2004**: LU, IE, HR; **2007**: EE, EL, MT, PT; Grade C unavailable for BG, RO (included in B)
Break in series: CZ (2005)
Provisional data: ES
Data estimated: EU-27, EU-25, EU-15 (by DG Research), SI
Head count
Some differences exist in coverage and definitions between countries
Country with small numbers of academic staff: CY, MT, LU, IS
NO: before 2007 biannual data

Women's under-representation in the higher levels of the academic hierarchy is reflected in the composition of the decision making committees and leadership positions that are mainly composed of men. Consequently, one observes a striking low presence of women in very high positions such as at the head of universities or other higher education institutions. Figure 18 illustrates well this phenomenon. On average throughout the EU-27, only 13% of institutions in the higher education sector are headed by women in 2007. We can see that this proportion varies from 27% to 0%. The countries that show the highest proportion of women are Norway, Sweden, Finland, Italy and Estonia (more than 19%). On the other hand, the countries that show a very low proportion of women in such leading position are Luxembourg, Denmark and Slovakia (under 7%). When considering only universities and assimilated institutions (institutions that are able to award PhD titles), the proportion is even lower. The average for the EU-27 shows that only 9% of universities have a female head. The highest shares of women rectors are observed in Sweden, Iceland, Norway, Finland, but also in Israel. On the contrary, in Denmark, Cyprus, Lithuania, Luxembourg and Hungary, no single university is headed by a woman. Romania, Austria, Slovakia, Italy, the Netherlands, the Czech Republic, Belgium and Germany have also very low proportions of women rectors (7% at most). When comparing these results with the proportion of women in grade A, it is obvious that the proportion of women continues to fall down when advancing up the academic ladder. The metaphor of the leaky pipeline is reflected everywhere.

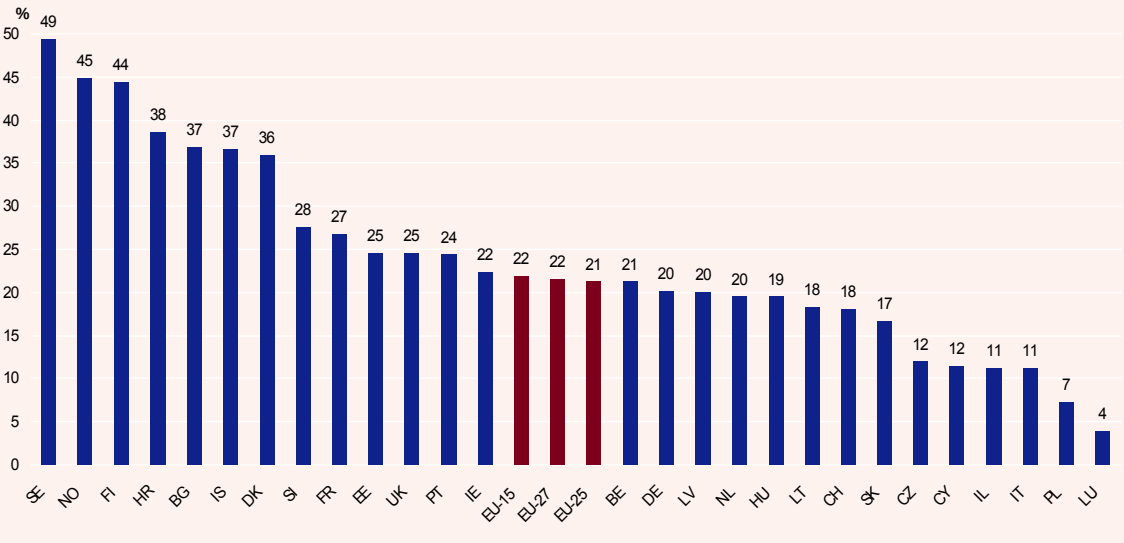
Figure 18: Proportion of female heads of institutions in the HES, 2007



Source: She Figure, 2009, p. 97, (EC , 2009b) 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

The proportion of women on boards adds interesting information to this overall pattern. Even if the coverage of boards differs across countries, one can state that in general, boards data cover scientific commissions, R&D commissions, boards, councils, committees and foundations, academy assemblies and councils, and also different field-specific boards, councils and authorities. These bodies wield crucial power on the orientation of research. Figure 19 presents data on the proportion of women on boards for the year 2007. For the EU-27 average, this proportion was 22% for that year. The Scandinavian countries show a particularly high proportion of women on boards. In Sweden, Norway and Finland, the share of female board members exceeds 44%. It is not surprising since in these countries, there is an obligation to have at least 40% of members of each sex in all national research committees and equivalent bodies. The countries that show the lower levels of women on board (less than 20%) are Hungary, Lithuania, Switzerland, Slovakia, the Czech Republic, Cyprus, Israel, Italy, Poland and Luxembourg.

Figure 19: Proportion of women on boards, 2007



Source: She Figure, 2009, p. 99, (EC, 2009b) 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 numbers of boards varies considerably over countries
BE data refer to French-speaking community

Data related to vertical segregation in sectors other than higher education do not exist. Data are available concerning the gender distribution of R&D staff within different occupations (researchers, technicians and others) for the higher education sector and also for the government, and business and enterprise sectors and for all sectors together, for the year 2006. According to the Frascati manual, researchers are "professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned"; while technicians are "persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers". Finally, other supporting staff include "skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects". These definitions allow one to distinguish a certain hierarchy among R&D occupations: researchers are placed at the highest level, followed by technicians and other supporting R&D staff. According to these data, one observes that for all countries and all sectors, the proportion of male researchers is higher than the proportion of female researchers. Among the two other levels (technicians and other), the proportion of women exceeds that of men.

Table 6 presents the values of the ID index measuring vertical segregation (across professional categories – ISCO88, 3-digits) for 3 populations: the total workforce, the population of researchers and the population of the most highly qualified researchers (with a Ph.D. degree) for all members of the EU-27 for 2007. Vertical segregation among researchers should be understood as a different distribution of male and female researchers over the hierarchy of professions. The table shows that vertical segregation in the population of researchers 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 researchers than in the labour market as a whole and it drops even further when one compares total researchers with the subsample of the most highly qualified researchers. In a second group including France, Italy, Romania and Bulgaria, the level of dissimilarity in the distribution over professional categories is higher when only researchers are concerned than when the total labour force is analysed. In all of these countries, the ID index, although higher for researchers than for the total workforce, is lower amongst the most highly qualified researchers (ISCED 6) than amongst researchers of all levels of education (ISCED 5A and 5B) and than for the total workforce. In Cyprus, Slovakia, Greece, and to a smaller extent in Estonia, professional dissimilarity is highest in the total workforce, lowest in the population of researchers and between these two extremes between the most highly qualified male and female researchers.

Table 6: Vertical segregation (ID-index): comparison of researchers with the total workforce, 2007

	Total population	Researchers (ISCED 5A, 5B, 6)	Researchers with a Ph.D. (ISCED6)
ES	0,47	0,24	0,12
CY	0,46	0,25	0,34
BE	0,45	0,26	0,14
GR	0,40	0,26	0,29
LU	0,45	0,27	0,10
NL	0,46	0,27	0,19
LT	0,53	0,29	0,12
PT	0,47	0,29	0,14
AT	0,49	0,30	0,27
LV	0,52	0,31	0,25
CZ	0,52	0,32	0,20
DK	0,46	0,33	0,19
FR	0,33	0,34	0,16
PL	0,42	0,34	0,26
DE	0,47	0,35	0,32
NO	0,47	0,35	0,09
UK	0,49	0,35	0,11
HU	0,52	0,36	0,27
EE	0,57	0,37	0,57
IE	0,51	0,37	0,12
FI	0,55	0,40	0,15
SK	0,54	0,40	0,44
SI	0,42	0,41	0,19
SE	0,47	0,45	0,11
IT	0,39	0,48	0,13
RO	0,39	0,52	0,24
BG	0,47	0,55	0,33

Source: LFS 2007, own calculations

Note: the figures in the last column relative to researchers who hold a Ph.D. degree should be interpreted with caution due to small sample sizes

3. Gender segregation in the Gender and Science Data Base

3.1. Synthesis and statistical analysis of the Gender and Science DataBase

3.1.1. General overview

The total number of publications coded in the gender and science database is 4549. Table 7 presents the presence of a topic among the total number of publications. The abbreviations used represent the different topics that are related to the issue of gender and science: HS: Horizontal segregation; VS: Vertical segregation; PG: pay gap and funding; SI: Stereotypes and identity; LA: Science as a labour activity; SE: Scientific excellence; RC: Gender in research content; PE: Policies towards gender equality on research.

Among the total of 4549 publications, 1965 are related to the topic “horizontal segregation” and 2035 are related to the topic “vertical segregation”. These two topics are, after stereotypes and identity (with 2458 publications), the areas of research that have been the most studied.

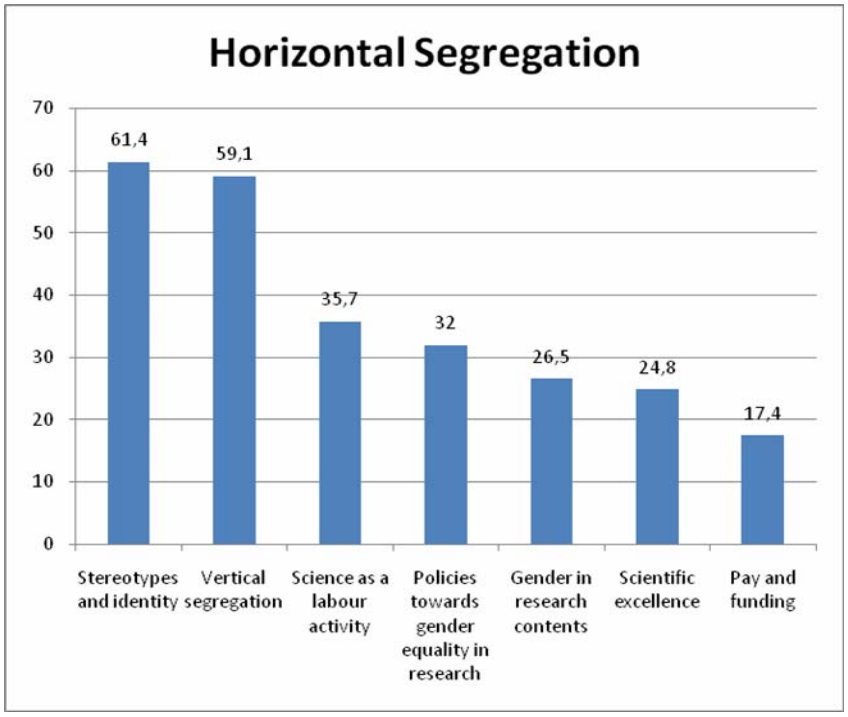
Table 7: Presence of topics in the publications of the database

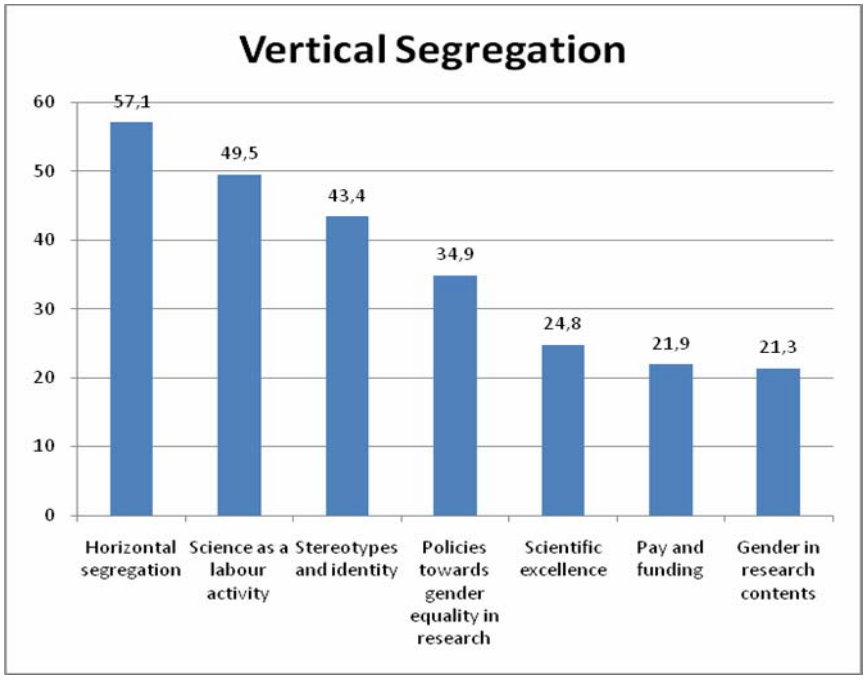
	HS	VS	PG	SI	LA	SE	RC	PE	Total
Number of publications	1.965	2.035	571	2.458	1.483	900	1.434	1.296	4.549

One can observe from Figure 20 that among the total number of publications that deal with horizontal segregation, an important number (61.4%) also deal with the topic “stereotypes and identity” and with vertical segregation (59.1%). These two topics are narrowly connected with horizontal segregation in comparison with other topics.

The situation concerning the publications on vertical segregation is a little different. The link with the other type of segregation (horizontal) is again very strong: 57.1% of the publications related to vertical segregation also deal with horizontal segregation. Vertical segregation is also narrowly linked to the topic “science as a labour activity” which is present in 49.5% of the publications on vertical segregation and, to a lesser extent, with the topic of “stereotypes and identity” (43.4% of the publications).

Figure 20: Presence of topics in thematical groups of publications





3.1.2. Institutional sector

Concerning the institutional sector, about half of the publications on horizontal segregation concern all sectors in general while for vertical segregation this percentage is 37% (Table 8). The higher education sector is the sector that has been the most investigated regarding horizontal and vertical segregation boasting 85% and 86% of total publications. It is followed by the government sector that is studied in 28% of the publications. The business enterprise and private non-profit sectors are less investigated.

Table 8: Institutional sector

Institutional sector	HS	VS
All/General	50,8	37,4
Other	49,2	62,6
Total	*100,0*	*100,0*

Institutional sector - Other	HS	VS
Business enterprise sector	12,0	12,7
Government sector	28,1	27,5
Higher education sector	86,1	85,0
Private non-profit sector	4,3	3,2

3.1.3. Scientific field of study

The statistical data concerning the scientific fields of study covered by the research (Table 9) shows that the most investigated field is science, mathematics and computing (50.6% for horizontal segregation and 47.4% for vertical segregation); followed for horizontal segregation by engineering, manufacturing and construction (29.8%) and for vertical segregation by the social sciences, business and law (34.2%).

Table 9: Scientific field of study

	HS	VS
Education	19,9	23,4
Humanities and arts	14,4	19,8
Science, mathematics and computing	50,6	47,4
Agriculture and veterinary	7,3	12,8
Health and social services	19,5	28,8
Engineering, manufacturing and construction	29,8	33,0
Social sciences, business and law	27,7	34,2
Services	0,9	1,2
Other	31,0	23,1

3.1.4. Life course stage

Table 10 shows that few publications concern the overall life course (20.8% for horizontal segregation and 16.2% for vertical segregation). The large majority of publications concern one or more age groups in particular. As it is shown by Table 12, the publications studying horizontal segregation mainly deal with early career scientists (65.1%) but also with mid-career and late-career scientists (59.8% and 57.0%) and to a lower extent, with tertiary education (42%). The publications regarding vertical segregation are more concerned with the latter stages of the life-course focusing on scientists' employment phases in their early career (84.3%) mid career (80.6%) and late career (76.9%); followed by 45.6% for the second stage of tertiary education and 34.6% for the first stage of the tertiary education.

Table 10: Life course stage

Life course stage	HS	VS
All/General	20,8	16,2
Other	79,2	83,8
Total	*100,0*	*100,0*

Table 11: Life course stage - Other

	HS	VS
ISCED 0	2,4	0,9
ISCED 1	7,7	2,2
ISCED 2	14,1	3,4
ISCED 3	18,8	6,0
ISCED 4	9,5	5,6
ISCED 5	42,2	34,6
ISCED 6	41,7	45,6
Early-career scientists	65,1	84,3
Mid-career scientists	59,8	80,6
Late-career scientists	57,0	76,9
Other	8,3	7,9

3.1.5. Methodological approach

In terms of the methodological approach used one can observe in Table 12 that all approaches have been used although constructing gender indicators is utilised in less than 5% of all publications. The research on horizontal segregation privileges the conceptual approach and the state-of-the-art at 38.6% and 38.5% respectively followed by the compilation of statistics and empirical research with qualitative techniques at 32%. Empirical research based on quantitative techniques constitutes 28.2% of the publications. Vertical segregation is mainly studied by way of a state-of-the-art methodology (42.9%), but also through a conceptual approach (32.4%), the compilation of statistics (33.3%), and empirical research with qualitative techniques (34.3%); and finally using quantitative techniques (27.4%).

Table 13 presents the type of empirical research that has been carried out by researchers to investigate horizontal and vertical segregation. No striking difference is observed between the two types of segregation. One can only mention the fact that vertical segregation has been more studied through qualitative techniques (24%) than with quantitative techniques (17%). The difference in the use of methods is not so noticeable for horizontal segregation (respectively, 22% and 18%). In general, for both types of segregation, qualitative techniques are used more than quantitative ones. Only very few publications use both quantitative and qualitative research methods (about 10%). Finally, nearly half of the publications from the Gender and Science Database do not present empirical research.

Table 12: Methodological approach

	HS	VS
Conceptual	38,6	32,4
State-of-the-art	38,5	42,9
Compilation of statistics	31,8	33,3
Building gender indicators	3,7	3,7
Empirical research. Quantitative techniques	28,2	27,4
Empirical research. Qualitative techniques	32,3	34,3

Table 13: Methodological approach: empirical research

Empirical research	HS	VS
No empirical research	49,7	49,0
Quantitative techniques	18,1	16,8
Qualitative techniques	22,1	23,6
Quantitative and qualitative techniques	10,2	10,7
Total	*100,0*	*100,0*

Among the use of quantitative techniques (Table 14), a representative sample is used in 56% of all publications on horizontal segregation and in 59.5% of publications on vertical segregation. Micro-data are used in 39.5% of all publications on horizontal segregation and in 48.4% of publications on vertical segregation. The use of multivariate analysis appears to be more common in the study of horizontal segregation (30.6%). Multivariate analysis for vertical segregation has been used in 24.9% of all research. Finally, few studies conduct longitudinal analyses (10.6% of all publication on both horizontal and vertical segregation).

Table 14: Methodological approach: Quantitative techniques

Quantitative techniques	HS	VS
Representative sample	55,9	59,5
Micro-data	39,5	48,4
Longitudinal/cohort	10,6	10,6
Multivariate analysis	30,6	24,9

Concerning the use of qualitative techniques (Table 15), interviews are conducted in an important number of the publications (65% for horizontal and 67.4% for vertical segregation). Bibliographical research is used in 16.2% of the publications on horizontal segregation while for vertical segregation, this percentage reaches 19.5%. Case studies constitute about 17% of the research on both types of segregation. The method of content analysis is applied in 18% of the research on horizontal segregation while this percentage is 14.8% for vertical segregation. This is more or less the same as for observations that is 16.4% of the research on horizontal and 11.0% of the research on vertical segregation.

Table 15: Methodological approach: Qualitative techniques

Qualitative techniques	HS	VS
Biographical research	16,2	19,5
Case studies	16,6	17,4
Content analysis	18,0	14,8
Interviews	65,0	67,4
Observations	16,4	11,0
Biographical research	16,2	19,5

3.1.6. Sub-topics of horizontal and vertical segregation

60.6% of publications on horizontal segregation deal with the distribution of female and male scientists and researchers over the different scientific fields, 17% look at the differences between institutional sectors and 22.4% do both (Table 16). The professional career is analysed in about 44% of the publications on vertical segregation and the gender composition of organisations in 18% (Table 17).

Table 16: sub-topics of horizontal segregation

Horizontal segregation	n	%
Scientific field	1.190	60,6
Institutional sector	334	17,0
Scientific field & Institutional sector	441	22,4
Total	*1.965*	*100,0*

Table 17: sub-topics of vertical segregation

Vertical segregation	n	%
Professional career	898	44,1
Gender composition of organisations	359	17,6
Professional career & Gender composition of organisations	778	38,2
Total	*2.035*	*100,0*

3.1.7. Evolution of the number of publications between 1980 and 2009

The evolution of the number of publications is relatively similar for both topics: horizontal and vertical segregation (Table 18). During the 80s the number of publications on horizontal segregation remained more or less constant (an average of 20 publications per year). During the 90s, the number of publications rose to an average of about 50 publications each year. The rise in the number of publications is even more visible after 1995. From the year 2000 there is an important impulse of research with an average of 123 publications each year. This increase is even more dramatic from the 2002 onwards.

As is the case for horizontal segregation, the end of the 80s shows a rise in the number of publications on vertical segregation. Research also seems to have been given a big impulse in the middle of the 90s (1995) and during the years 2000-2004. For the whole period, we observe that the number of publications is rising constantly: the average for the 80s is 17 publications by year; for the 90s, 54 publications by year; and for the years 00s, the average is 133 publications every year.

Table 18: Number of publications between 1980 and 2009

Publication year (mean per year)	HS	VS
1980-1984	14,2	11,6
1985-1989	25,0	21,8
1990-1994	40,4	36,0
1995-1999	68,2	72,2
2000-2004	127,6	146,0
2005-2007	159,3	157,3
2008-2009	55,0	62,5

Table 19: Time coverage

Time coverage	HS	VS
General / Not specified	2,3	3,8
Before the 18th century	1,4	1,2
18th century	1,3	1,4
19th century	6,0	6,7
1900-1945	11,9	12,8
1946-1970	16,0	16,7
1970s	21,6	21,7
1980s	35,2	33,4
1990s	50,8	51,7
2000s / Present-day	47,5	48,0

3.1.8. Horizontal and vertical segregation by country group

Table 20: Horizontal and vertical segregation by country group

	Nordic	Anglo-Saxon	Continental	Southern	Eastern
Horizontal segregation	606	542	610	495	337
Vertical segregation	513	477	821	525	378

Regarding horizontal segregation, we see that it is the Nordic, the Continental and the Anglo-Saxon countries that have published the most (Table 20). The Eastern countries published the less. Concerning vertical segregation, it is the Continental group of countries that have produced the highest number of publications with 821 entries. The eastern countries produced only 378 publications.

3.1.8.1. Scientific fields by country group

With respect to horizontal segregation, the most investigated field is that of science, mathematics and computing in all country groups, followed by engineering, manufacturing and construction in the Anglo-saxon, Continental and Eastern counties (Figure 21). In the Nordic and southern countries, the second most extensively studied field is that of the social sciences, business and law. Humanities and arts are an important field in the Nordic and Eastern countries.

Concerning vertical segregation, in all country groups, the field that is the most studied is science, mathematics and computing (Figure 22). Research in the Nordic countries appears to cover a larger range of fields: Health and social services are more addressed than in any other country group (41), the same is true for agriculture and veterinary (24,7).

Figure 21: Horizontal segregation: scientific fields by country group

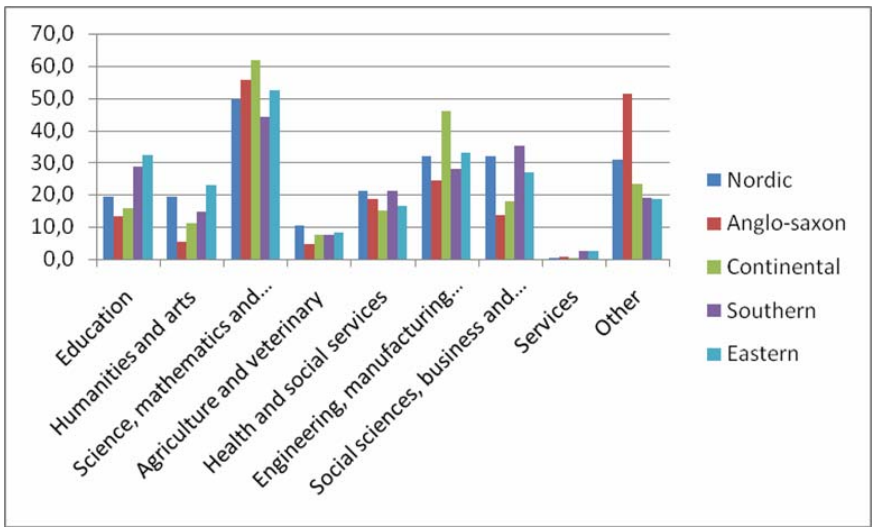
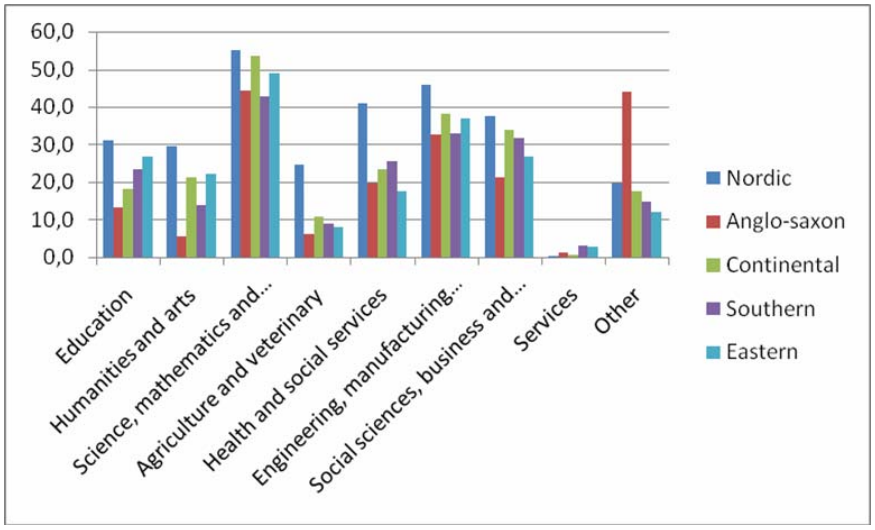


Figure 22: Vertical segregation: scientific fields by country group



3.1.8.2: Methodological approach by country group

The conceptual approach is more widespread in the Nordic countries, compilations of statistics and state of the art reports are more used in the Eastern countries, and the Anglo-saxon and Southern countries make a wider use of empirical techniques, both qualitative and quantitative (Figures 23 and 24).

Figure 23: Horizontal segregation: methodological approach by country group

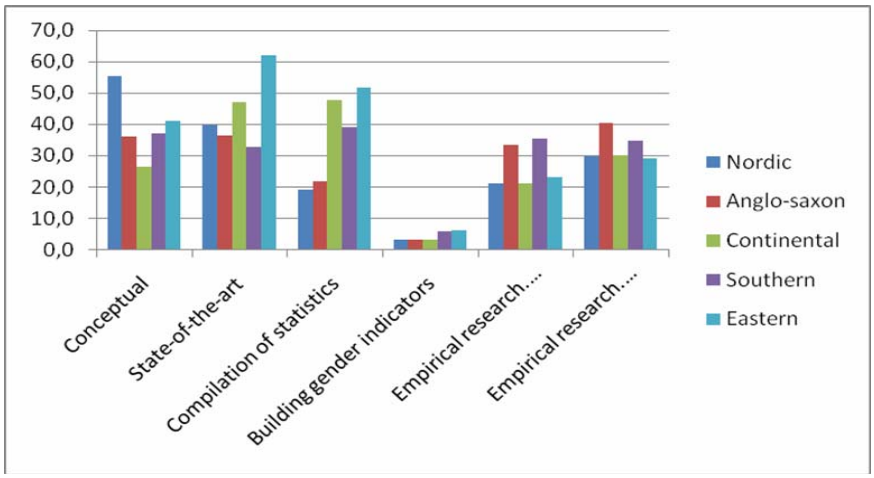
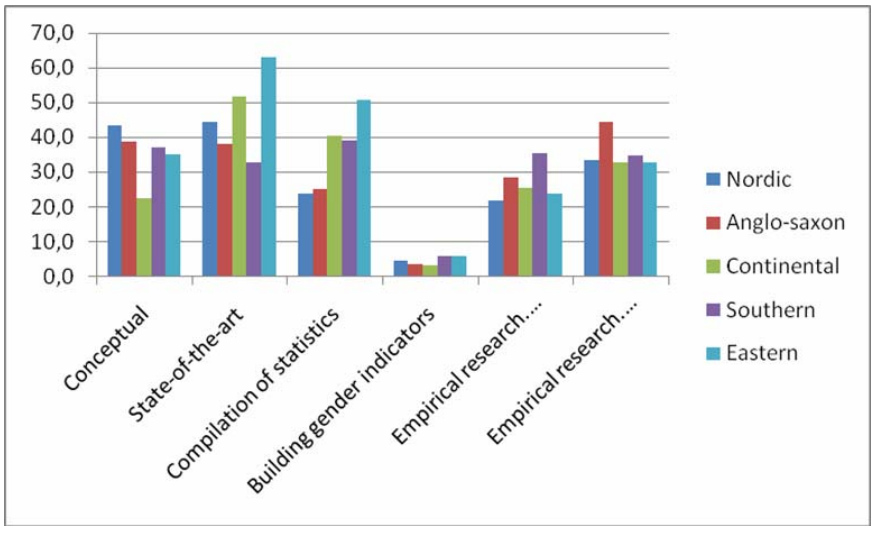


Figure 24: Vertical segregation: methodological approach by country group



3.1.8.3: Years of publication by country group

The profiles of the graphs are quite similar for the different country groups. We notice that the Continental countries have started to address the problem of segregation a little earlier than the other country groups (Figures 25 and 26).

Figure 25: Horizontal segregation: years of publication by country group

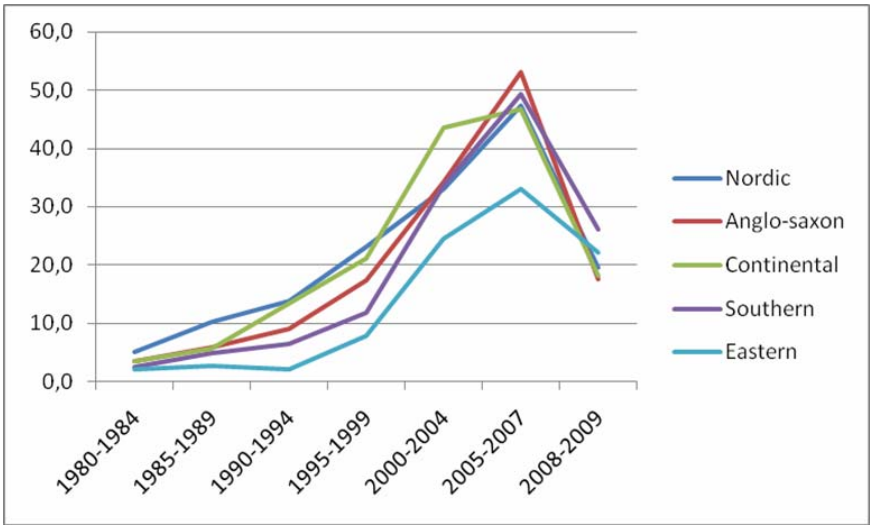
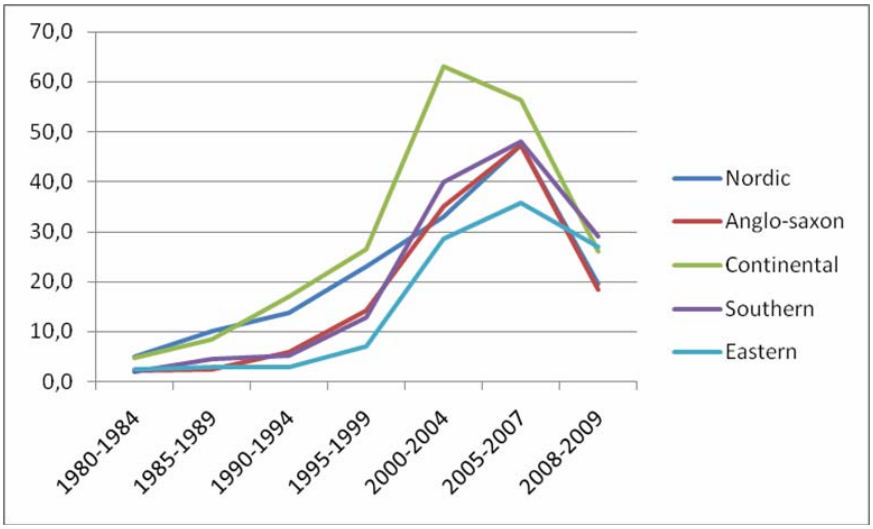


Figure 26: Vertical segregation: years of publication by country group



3.2. Research questions

3.2.1. Horizontal segregation

In the literature on horizontal segregation, two areas of research can be distinguished. The first research area concerns the study of the differences between girls and boys in education and scientific fields of study. The second research area is the analysis of segregation in the labour market and in scientific or research occupations, which could partly overlap with gender differences observed in education. The following section presents the research questions extracted from the database by these two sub-categories.

3.2.1.1. Educational segregation

The research concerning educational segregation in science starts with the analysis of the over or under representation of women and men by field of study. How are women/girls and men/boys represented across the main scientific fields at different school levels? The repartition of students by field of study among high school pupils and university students has been investigated in many publications.

The repartition of women and men by study field has also been studied over time in order to evaluate the evolution of the situation of men and women in different study fields. This allows one to identify recent tendencies in women's distribution over different areas of science and to reveal any (de)feminization/(de)masculinisation of certain fields of study.

Women's representation in a particular scientific field is another subject of concern. In a first stage, the natural sciences were studied most (during the 80's and at the beginning of the 90's). An example is the field of medicine and healthcare that has received particularly wide research attention in several countries. This is maybe due to the fact that funding opportunities for research in this area are greater than in the social sciences. The question of the gendered distribution across different specialties/orientations of the medical career was an important subject of concern. However, over time, other disciplines such as mathematics, physics, computer sciences, engineering, and science and technology have been investigated with regard to their gender composition.

Later, the low presence of women in technology took more importance. The field of technology has been studied on the basis of three questions:

- How and why do girls and boys have different relationships to technology?
- How do men and women experience and how are they treated within technological education?
- What are the initiatives to recruit women to natural sciences and technological education?

Concerning the Eastern countries, the interest in gender and science and the unequal distribution of women and men over fields of science is very recent (since 2000). One reseaon is that horizontal segregation was less pronounced in this group of countries.

After having identified the over and under representation of women across disciplines in education, the question of the mechanisms and factors that cause this situation is increasingly investigated. The gendered choices of education and how their early orientations (during primary and secondary education) affect orientations at university level is an important research question concerning the issue. The question of women's distribution over study fields in secondary and higher education has been largely investigated. What are the reasons why women and men start their studies in natural sciences, technology or engineering and how do these reasons differ? An important issue is whether gender differences in study choice are related to gender differences in educational performance, especially in maths. Although in

many countries girls and boys now have similar levels of performance in maths, the choice of study field remains largely gendered.

Gender roles, stereotypes and socialisation during infancy are the first kind of factors investigated in order to understand when segregation starts (Jacobsen and Højgaard, (eds.) 1990; Steen Pedersen, 1983; Bron-Wojciechowska, 1995; Duru-Bellat and Terrail, 1995; Marry, 2000; Blättel-Mink, 2002; Frank, 1990; Horstkemper, 1992; Bjerre, 1983; Kracke, et al. 1996). The analysis of the mechanisms that reproduce gender stereotypes throughout infancy and adolescence and their impact on the selection of an educational path have been studied. The impact of the socialisation process on study orientations was analysed in many countries. The effect of popular prejudice about the research career and the scientist on youth's choice of education has also been a subject of concern as well as the perception of the scientific lifestyle or science in general. The teaching cultures in different disciplines have been studied in Germany (Schaeper, 1997).

The gender differences in performance and ways of learning have also been questioned across different educational levels.

Women's experiences during their studies (hopes and expectations) were largely investigated as well as their attitudes towards science (Lie and Sjøberg, 1984; Kotarinou, 2004; Palasik, (ed.) 2006; Benckert, 1997; Osborne, et al. 2003; Reid, 2003; Fraser, 1994; Barbero García et al. 2007). The question of the degree of willingness of secondary school pupils to become scientists was investigated.Whether science education for science and a career in scientific research represents an option for female students - is a question that is raised in many researches. The question of the underachievement of boys has also been studied (Burns and Bracey, 2001; Carrington, and McPhe, 2008; Christine, 2000).

Finally, there are research questions that concern the measures and the actions that can be taken in order to decrease gender segregation in education. What can be done to balance out the gender proportions? How can scientific disciplines with few women/men attract more students of the opposite sex?

3.2.1.2. Occupational segregation

Occupational segregation could be partially linked to educational segregation. The question here is to understand what are the links between educational and occupational segregation by gender? Does the 'gendered nature' of study orientation in the educational system account for the persistence of gender segregation in technical and scientific professions and to what extent? Are career decisions gendered?

Data have been collected on the over/under-representation of women in science activities according to different R&D sectors. However research on that subject remains limited to the compilation and the description of the data, if available. Few publications propose deeper analysis of the phenomenon. Moreover, research on horizontal segregation of scientific women in the labour market mainly concerns the academic sector. The lack of homogeneity of research questions limits the analysis to several areas of research and particular questions on the topic.

When the data are available, the gender repartition across professional fields and sectors (universities, public and private research institutions) is analysed. For example, the share of women in occupations such as engineers, physicians, dentistry, the medical profession, academic positions or occupations in the ICT sector have been reported. A German study investigated the erosion versus persistence of gender asymmetries in modern management organisations from the ICT sector (Schraps and Hoff, 2005). The feminisation of academic staff and certain departments in the university constitutes another strand of research (Gadrey, 2006; Fave-bonnet, 1999; Alemany, 1991; Michel, 1988). Feminisation of non university institutions has also been analysed (Miller and Clark, 2007; Soares Machado, 2003, for the medical profession; Marry, 1989, 2001, for the profession of engineer; Šporer, 1987, Andreani, 1992; Barreira Lopes, 1987; Glover, 1999). The gender composition of scientific staff of universities and non-university research institutions is described and can be used as an indicator for gender inequality.

Regarding this one can mention an interesting research question: does the feminisation of a discipline entail a progressive loss of social value and rank for the entire discipline?

The historical development of women's admission to university and women's participation in the academic (scientific) community generated an important number of studies.
Some studies try to provide an explanation of the asymmetric gender ratios in several scientific and technical disciplines. What are the individual reasons for women's but also for men's choice of job or professional field?

In several cases a cultural analysis of the scientific institution is carried out in order to study the reasons for and practices of discrimination against women in science. In this respect, the study of the various patterns of women's representation in different occupational fields (employment status, type of contract, career structure, research and teaching, grant applications) are important structural factors that can affect the horizontal gender segregation. The organisational and disciplinary cultures in which low female representation is reproduced have been investigated. There is also much research that analyses the minority position that women hold in the most male dominated education and research milieus that explore how this position negatively affects women. One can further mention the development of studies that analyse the gender role perceptions of males in 'female' careers (Tracey and Nicholl, 2007).

In Israel, the influence of immigration on the occupational status of male and female immigrants from the former Soviet Union constitutes an area of research (Notzer and Brown, 1991, 1995; Bernstein and Shuval, 1999).

Box 1: Gender differences in the process of occupational integration of immigrant physicians in Israel

Bernstein and Shuval (1999) investigated the gender differences in the process of occupational integration of immigrant physicians in Israel. In this country, the immigration of more than 13,000 physicians, over half of whom were women, from the former Soviet Union during the first half of the 1990's, provided an opportunity to investigate gender differences in the occupational integration of a large group of professionals. The study presents findings from a three-stage cohort study of 333 former Soviet physicians covering their first five years in Israel, and from in -depth interviews with twenty-three immigrant physicians. After two and a half years in Israel, male respondents were more likely to be working in their profession than female respondents, who were more likely to be unemployed. After five years, men and women were equally likely to be working as physicians, but the men were significantly more likely to be in residency programs to attain specialty status, while the women were more likely to be working as general practitioners. The authors suggest that gender differences in professional behavior were intricately related to traditional gender-related family norms which persisted throughout the Communist era. The tendency for some of the women to delay resuming their career in Israel is seen as adaptive in the context of migration, because it provides continuity of self-identity and family norms. Furthermore, women who chose to work as general practitioners saw this work as a continuation of their work in the USSR. After five years in Israel, there were no gender differences in work satisfaction, self-esteem, mood and general adaptation.

Bernstein, J. H. & Shuval, J. T. 1999, 'Gender differences in the process of occupational integration of immigrant physicians in Israel', *Sex Roles*, vol. 40, no. 1-2, pp. 1-23.

The research also includes overviews and evaluation of equality measures deployed throughout the various institutions. The impact of legislative changes has been investigated. Research was also carried out on the range of possible measures employed to change this situation. Recommendations for further actions are proposed as well as practical interventions that could be introduced to support the promotion of female academics in scientific and technological fields in universities.

Finally, one can mention a particular characteristic concerning the research questions from the Eastern countries. Among those countries, the research often focuses on the differences between the socialist and capitalist periods. How did the changes after 1989 affect women's education and careers (especially in science fields)? The main issue is that horizontal segregation has increased substantially during the transition period and as such it has become more widely investigated.

3.2.2. Vertical segregation

Most of the research on vertical segregation concerns the higher education sector and more precisely universities. Research concerning other sectors (governmental, business and enterprises sectors) is very limited. The following section will be divided into two parts, the first one synthesizes the research questions relative to the academic sector, and the second part presents the studies dealing with the other sectors.

3.2.2.1. Academia

The research concerning vertical segregation in academia generally starts with a descriptive overview and analysis of the statistics on the representation of women and men across the hierarchical levels. The picture of the distribution of women through the academic hierarchy can be looked at by scientific field, by faculty, for the whole university or for more than one university (national statistics). The gender composition of the staff in universities is presented.

In many cases, it is the description of the under-representation of women in higher or management positions (glass ceiling) that constitutes the starting point of discussions on the causes and explanations for segregation. There is on the one hand, the analysis and identification of the causes and of the mechanisms pertaining to vertical segregation, and on the other hand, the analysis and identification of the consequences induced by this type of segregation.

The phenomenon of the "leaky pipeline" (the leaky pipeline portrays gradual "disappearances" of women from the scientific career ladder with growing scientific achievement) is often investigated (Tænketank om flere kvinder i forskning 2005; Jungersen 1997; Borchorst, 1995; Kofod, 1998; Langberg, 2006; Henningsen, 2002; Henningsen and Højgaard, 2002; Linková, 2002) The questions addressed are: what is stopping women's careers? Why do women need longer to become seniors or professors? Why do women usually face great difficulties in developing professional careers? On which level of the different stages of an academic career – students, doctoral students, teaching and academic staff, post-docs, assistant professors – do women leave and for what reasons? Indeed, women are in general equally represented or even over represented in low hierarchical levels but they are underrepresented in the power structures and higher posts.

The drop-out rate of women is in some cases analysed in a specific field of study in comparison with other disciplines in order to find any differences or particularities (Jensen, et al. 2005, for the field of engineering).

The dynamics of scientific promotion of female and male academics and researchers have also been questioned as they could constitute a barrier for women's advancement in the academic career. The neutrality of such promotion and evaluation processes is often questioned. Which factors are taken into consideration in the evaluation? Is the selection procedure gender neutral? The research tends to prove the discrimination towards women.

The (patriarchal) culture of the university and of science in general is analyzed and questioned as well as the historical tradition of male-dominated fields. The patterns and status of women's employment are investigated in this regard.

Finally, a part of the research is dedicated to the search for measures that can retain women graduates as researchers in academia. How can society as well as the academic system be changed to be more inclusive towards women? Gender equality measures in these institutions are evaluated in their findings. Recommendations for further actions are presented such as gender mainstreaming measures and reform strategies to address these barriers. Several studies propose a comparison of best practice models for promoting the career progression of female academics in Europe, especially in sciences and technology.

3.2.2.2. Other/all sectors

Apart from the studies on vertical segregation in academia, one can mention other research that concerns the government or private sector, or all sectors in general.

Women's career paths in science have been investigated through questioning how and what kinds of women pursue a career in science and how does it differ from men's career paths? The question of whether women are better represented in the leading positions in non-university scientific institutions has been investigated. The lack of women's power in administrative management positions in educational and professional institutions also constitutes an important area of research. The unequal treatment of women in science has also been analysed as well as the push and pull factors of segregation (women's interests, the educational preconditions and socialization). Identifying the crucial points or stages where women drop out, don't qualify or make progress throughout the scientific carrer have also been studied. More generally, the overall setting and background of scientific institutions, scientific practice and excellence have been investigated.

Career progression has been investigated in various scientific fields[1]: engineering (Singh, 2000; Wächter and Thaler, 2004; Thaler, 2006; Marry, 1992; Artal Serrat et al. 2000); bioengineering (Wittberger, 1999); mathematics (Branner, et al. 1996) medicine (Newton and Thorogood, 2000; Shaw, 1980; Wakeford and Warren, 1989; Crompton and Lyonette, 2007; Williams 2000; Hohner et al. 2003; Lambert and Goldacre, 2002); ICT (Griffiths, et al. 2006, 2007; Adam, et al. 2004; Stevens, 2007; Ercolani, 2005; Valgaeren, 2005); in physics (Пройкова и др. A. [Proikova et al], 2005; Antal, 2000; Abele, E. 2003); economy (Rudolph, 1999; Pomata, 2002,); chemistry (Wiemeler, 1996); radioactivity (Palló, 2000); psychology (Popper, 1989; Hoff, et al. 2003); biology (Lüchauer, 2002); geography (Zawadzka, 2007); architecture (Caven, 2006); geology (Kecskeméti, 2000); veterinary (Felker, 2004) ; dentistry (McEwen and Seward, 1989; Murray, 2002). Among these studies, the analysis of the organizational culture is very recurrent.

Finally, one can mention the reflections on possible changes in the occupational structures, and in the organisational culture. The impact of legislative changes, or implemented equal opportunity measures have also been analysed.

3.3. Methodology

It is worth noting that the research is mainly concentrated on universities and academia. Very few countries present investigations that concentrate on scientific professions in other sectors (public/government sector: Greece, Israel; Lithuania; business and private sector to a lesser extent: Austria).

Researchers have sometimes applied feminist theories when attempting to explain segregation (Wahl, 1991; Del Bo Boffino, 1990 ; Öhman, 2001; Cronin and Roger, 1999; Hager, 1997; Pantelidou Malouta, 1987; Koivunen and Liljeström, (eds.) 1996; Berg, 1998). Some studies are of a theoretical and conceptual nature and focus on the contribution of feminist criticism to the reformulation of science namely in questioning the barriers between disciplines (Nogueira, 2001). Feminist theories have also been criticised or complemented (Lotherington and Markussen, (eds.) 1999; Carrera Suárez et al., 1999; Åsberg, 1998; Birbaumer and Tellioglu, 1999; Karaduman, 2006).

[1] This is a non-exhaustive list of publications.

Box 2: Feminism and Science

The new Oxford Readings in Feminism series maps the influence of feminist theory on every branch of academic knowledge. Offering feminist perspectives on disciplines from history to science, each book assembles the most important articles written on its field in the last ten to fifteen years. Old stereotypes are challenged and traditional attitudes upset in these lively-- and sometimes controversial--volumes, all of which are edited by feminists prominent in their particular field. Comprehensive, accessible, and intellectually daring, the Oxford Readings in Feminism series is vital reading for anyone interested in the effects of feminist ideas within the academy. Can science be gender-neutral? In recent years, feminist critics have raised troubling questions about the practice and goals of traditional science, demonstrating the existence of a pervasive bias in the ways in which scientists conduct and discuss their work. This exciting volume gathers seventeen essays--by sociologists, scientists, historians, and philosophers--of seminal significance in the emerging field of feminist science studies. Analyzing topics from the stereotype of the "Man of Reason" to the "romantic" language of reproductive biology, these fascinating essays challenge readers to take a fresh look at the limitations--and possibilities--of scientific knowledge.

Keller, E. & Longino, H. 1996, *Feminism and Science*, Oxford University Press, Oxford.

State-of-the-art literature review is also an important part of the research. The aim here is to give a conceptual framework that introduces the subject and give a better understanding of the problematic.

The study of vertical and horizontal segregation in most cases start with a descriptive overview based on available statistical data (general statistics and register based data provided by the institutions) on the share of women at: a) the main educational levels, b) across the main scientific fields, c) across research and scientific occupations, d) along hierarchical levels, e) among professional associations. Data on the achievement of men and women in certain disciplines have also been collected using various exam scores and matriculation grades (Birenbaum and Nasser, 2006; Vogt, 1996; Chatard, et al. 2007; Köse, 1998; Beller and Gafni, 2000; Altinok, 2004; Canca, 2005; etc…). Admission scores by gender have also been collected (Almeida et al. 2006; Gafni, et al. 2002; Azen et al. 2002; Henningsen, 1998; Čermáková, 2000; Predin, 2000).

The data used in these articles is either a compilation of different data or it comes from a large survey. In all countries there are publications on the share of female students and graduates, staff of scientific institutions in different hierarchical positions and different scientific fields. Statistical data on the share of women among administrative staff and executives, as well as in committees involved in science policy-making, are also analysed. The historical and present situation when it comes to horizontal segregation is mainly accounted for by the analysis of statistics. This descriptive work forms the basic research.framework. The description of segregation requires the availability of data which are often missing. In some cases, recent research analyses information obtained throughout online questionnaires (Mischau et al. 2006; Palasik, (ed.) 2008).

Historical overview of the two types of segregation and the share of women is often carried out. The temporal development of occupational status was investigated in Israel. The historical approach was often used in the Eastern countries in order to draw a comparison between the former socialist regime and the actual one whilst the implications of this shift are charted regarding women and science. These studies highlight the influence of specific gender policies implemented in these countries during the communist and the post-communist epochs. The context of economic, social and political transformations and their outcomes have particular importance in these studies. However, research in this field is very scarce.

There are also statistical comparisons:

- Comparison of data on women's status in different sectors.
- Comparisons may focus on the performance data for students by gender and by disciplines.
- Comparative studies that explore data from across Europe- comparing statistics from one country with other countries in terms of numbers of women in different occupational levels.

The comparative approach is used in several cases to compare different countries situations (cross-country analysis). The international comparisons use a common quantitative and qualitative methodology in all partner countries.

Box 3: Women's participation in positions of responsibility in careers of science and technology: obstacles and opportunities

A methodological study questioning how to investigate the phenomenon of women's under-representation in science and in the top positions has been carried out by Stolte-Heiskanen (1988). According to the author, 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, and the problems revealed are assumed to pertian particularly to women scientists. From a methodological point of view, the validity of generalizations concerning women scientists must rest on the demonstration that they are gender specific. This implies the need for systematic comparisons of men and women scientists. A review of literature shows that most of the research on women's careers in science is concentrated 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 organization of science and culture of the scientific community 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.

Longitudinal data are often used in order to show the growing presence of women in universities ("massification" and feminization of universities), in disciplines and to show the evolution between generations (Verlinden, et al. 2006; Mastekaasa and Smeby, 2008). It is also used to explain the occupational segregation (Abele and Stief, 2004; Schoon, 2001). Longitudinal studies on vertical segregation have also been carried out (Abele, 2003; Baker, 2000; Palomba, 2000; Van der Burg, et al. 1998).

Box 4: Segregation (M/W) in Flemish Higher Education: Underestimated or Overestimated?

There are big differences between men and women concerning their work and function, the sector of work and wage. The objective here is to examine women's employment in the higher education sector on the basis of descriptive statistics. Longitudinal data on the academic and scientific staff in Flemish universities are provided for the period from 1992 to 2002.
Conclusions are that equal opportunities policy for boys and girls from the historical perspective of democratisation of high education apparently has been successful. In the higher education system the presence of women in the teaching staff has become obvious. Their part lies even higher than the average in the labour market. In universities the proportion of women is lower. Women are generally present in lower function levels. In universities and the higher education system, the highest and best paid functions are heavily under-represented.

Steegmans, N. 2003, *Segregatie (M/V) in het Vlaamse Hoger Onderwijs: Onderschat of Overroepen?*, Steunpunt gelijkekansenbeleid - contosium Universiteit Antwerpen en Limburgs Universitair Centrum, Antwerpen.

Research studies in the beginning of the 1980 and 1990 were mainly quantitative -describing differences in academic careers, and showing the numerical under-representation of women. Later on, more qualitative studies, based on interviews and also historical research, put more emphasize on the mechanisms underlying this underrepresentation and absence of women in some academic disciplines and organizations. The descriptive work is then combined with a deeper analysis of the reasons that can explain this under representation of women. The aim here is to fill in the gaps in the explanatory power of the descriptive work and strengthen the quality of the research.

These data could be provided by institutions or as a result of quantitative empirical studies based on survey. Generally, the quantitative studies are descriptive. However, more advanced regression techniques (multivariate analysis) have been used (Risberg, 2004; Berggren, 2006; Rosén, 1998; Bilgin and Geban, 2004; Buddeberg-Fische et al., 2006; Soylu, 2006).

There are also many qualitative studies based on interviews, which helped to reveal women's (or men's) attitudes, experiences, opinions and perceptions. These interviews are carried out with masculine and feminine staff members from scientific institutions but also with students. In some other cases the method of the focus groups (Wächter and Thaler, 2004; Garforth and Kerr, 2008; Deem and Brehony, 2000; Sagebiel and Dahmen, 2008; Tarihci Delice, 2008; Beck et al. 2006; Þorvaldsdóttir, 2001; Schlichting et al., 2007) or workshop (Wachter, 2002, 2003; Gunnarsson, 1994; Langberg, 2006; Triantafyllou, 2005) is used in order to gain rich data on individual's experiences. It allows one to analyse the motivation of their decision regarding their field orientation and career. It also gives information of the various obstacles women meet in their career and it informs on whether or not they perceived any kind of gender discrimination. These kinds of methodologies appear to be relatively new since they apply to the last ten years.

Biographic research has been carried out in 19 countries. This research is important because it attempts to generate a deeper understanding of segregation and because it reflects on the strategies and personal qualities that have been instrumental to acheiveing a successful career and overcoming the common constraints. Biographic investigations mainly concern the teaching staff of universities and are based on personal experiences. Other used qualitative methods are based on observation. The empirical observations are in most cases compared with the scientific literature. Case studies or content analysis are also used as a complement of the non representative quantitative studies.

In lots of cases, research combines quantitative and qualitative methodologies. These are statistical studies combined with interviews and questionnaire methods targeting HE institutions, companies, and sectors.

Analysis of the causes and factors for the lack of women in male-dominated fields:

- Social explanations for young people's decision on study orientation and attitudes towards science are put forward in the publications on horizontal segregation and are essentially based on qualitative methods. Authors have explored the influence of the family and of teachers' behaviour in the classroom or the role of careers advisors. The images of sciences and representations linked to female and male identities are also discussed as are possible measures to improve the situation. Most of the studies adopt similar approaches and work on the links between coeducation, vocational guidance, social and psychological factors.
- A few authors propose different analyses that, without denying that girls experience a different outcome than boys, consider the choices that girls make as "rational" and strategic to adapt to their future social roles. This approach however is not always based on the premise of role-adaptation as other issues may be behind girls' choices.

Research on vertical segregation focuses on analysing the mechanisms that provoke the glass ceiling, women's personal barriers, the functioning of the scientific community, and the general environment etc. Early research consisted of describing the career paths of female scientists and the barriers they experience in developing scientific careers. The problem of vertical segregation in professional careers went from observation of direct discrimination to the study of more subtle forms of discrimination. This explains why the gender composition of organizations has become a research focus of vertical

segregation, as male dominated boards and decision-making committees are recognized as a key mechanism of discrimination.

This research can be done through the exploration of a wide range of factors, professional circumstances, and employment sector to identify where gender has an impact. Factors such as prioritising between private and professional life, the family composition, the attitudes towards career, motherhood ideology, productivity rates, the institutional culture, the institutional structure, the gender stereotypes in the evaluation and promotion system have all been examined.

Box 5: Measurement of vertical and horizontal 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 female talent. 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 concentration 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.

Some researchers have created and proposed indicators to measure the "glass ceiling" (Navarro Guzmán et al. 2008; ISTAT, 2001; Benigni et al. (eds.) 1988).

Box 6: The design of indicators for the analysis of the gender segregation of the university teaching staff

Many different countries' institutions and universities, including Spain, are taking measures to evaluate the magnitude of barriers and the forms of inequality in higher education. On the basis of this work policies are being designed and implemented to tackle these barriers and inequalities. The research on the situation of women in Spanish universities until the present date shows that since the 70's the entrance of women into the university system has been increasing, but is highly differentiated by field. Although outright exclusion has been surpassed, at present, situations of discrimination and segregation by gender can be observed. It therefore becomes necessary to deepen the analysis and study available data with the aim of obtaining a non distorted image of the state of the question. Diverse studies about social indicators of equality highlight that the analysis of gender segregation in the university context requires a set of objective indicators and quantitative data that must be available for collection and analysis from the institution. , A system of indicators has been developed that has been used to elaborate a report on the Situation of Equal Opportunities of Opportunities at the UIB (Universidad de les Illes Balears).
Navarro Guzmán, C., Cano Juan, S. & Ferrer Pérez, V. 2008, 'Diseño de indicadores para el análisis de la segregación por género del profesorado universitario' in Observatori per la Igualtat. Universitat Autònoma de Barcelona, ed. *Actas del I Congreso internacional sobre sesgo de género y desigualdades en la evaluación de la calidad académica*, Universitat Autònoma de Barcelona, Bellaterra, pp. 227-234.

Finally, one can mention the policy-oriented and action research. Studies have analyzed the effectiveness of Equal Opportunities policies and measures. These are self-assessment studies evaluating the effectiveness of support systems in place in universities to support/promote women in SET (including literature reviews, surveys, interviews and focus groups). In Germany, the evaluation of the implementation of the first single-sex degree course was carried out.

3.4. Results

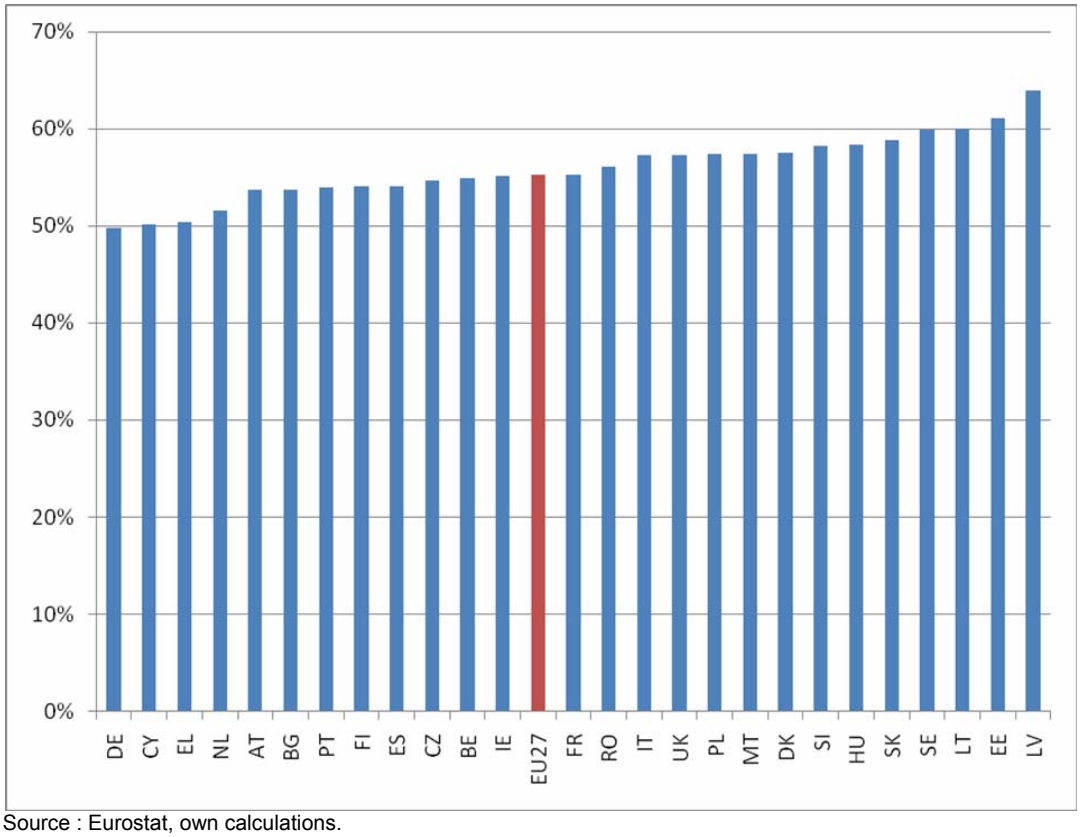
3.4.1. Horizontal segregation

3.4.1.1. Education

A. Description of educational segregation

During recent decades, there has been a strong increase in the presence of women amongst students enrolled in tertiary education across the board. The proportion of women among all students enrolled in tertiary education in 2007 varied between 50% and 64% throughout the EU27 (Figure 27). The lowest share of female students in tertiary education is found in Germany, Cyprus and Greece and the highest share Sweden, Lithuania, Estonia and Latvia.

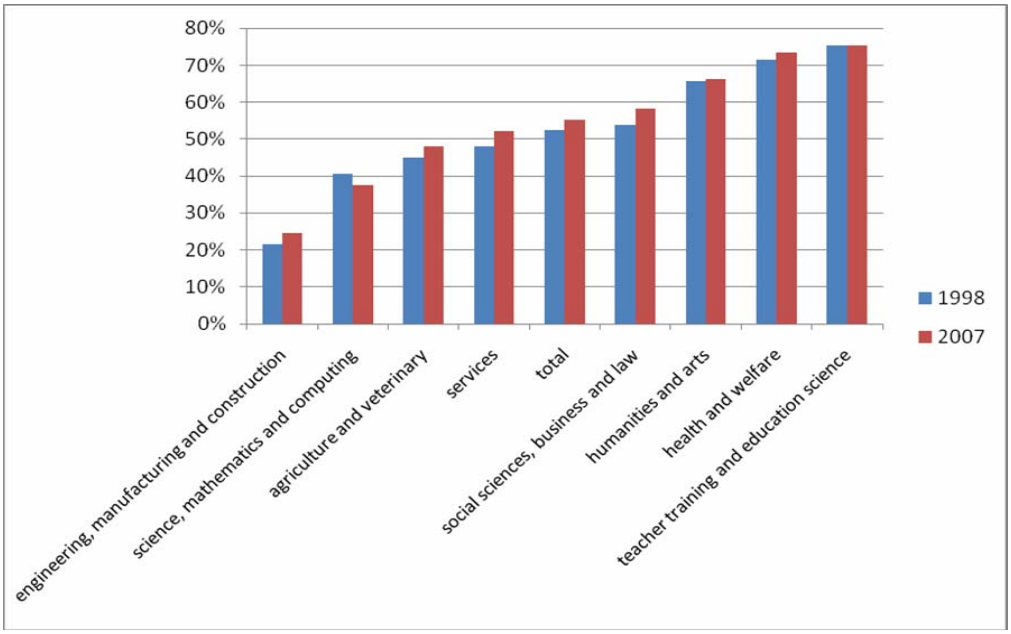
Figure 27: The proportion of female students enrolled in tertiary education (ISCED 5-6) across the EU27 in 2007



Source : Eurostat, own calculations.

On average, at the EU27 level, the share of women among all students enrolled in tertiary education, increased from 52% in 1998 to 55% in 2007 (Figure 28). This increased presence of women in tertiary education has led to an overrepresentation of women in certain fields of study (social sciences, business and law, humanities and arts, health and welfare and teacher training and education science) and a movement of female students catching up with male students in services and agriculture and veterinary. One study field appears to resist to these trends: in science, mathematics and computing, the proportion of women is around 40% but it has decreased between 1998 and 2007. In engineering, manufacturing and construction, the share of female students remains the lowest but it has increased over time, from 22% in 1998 to 25% in 2007.

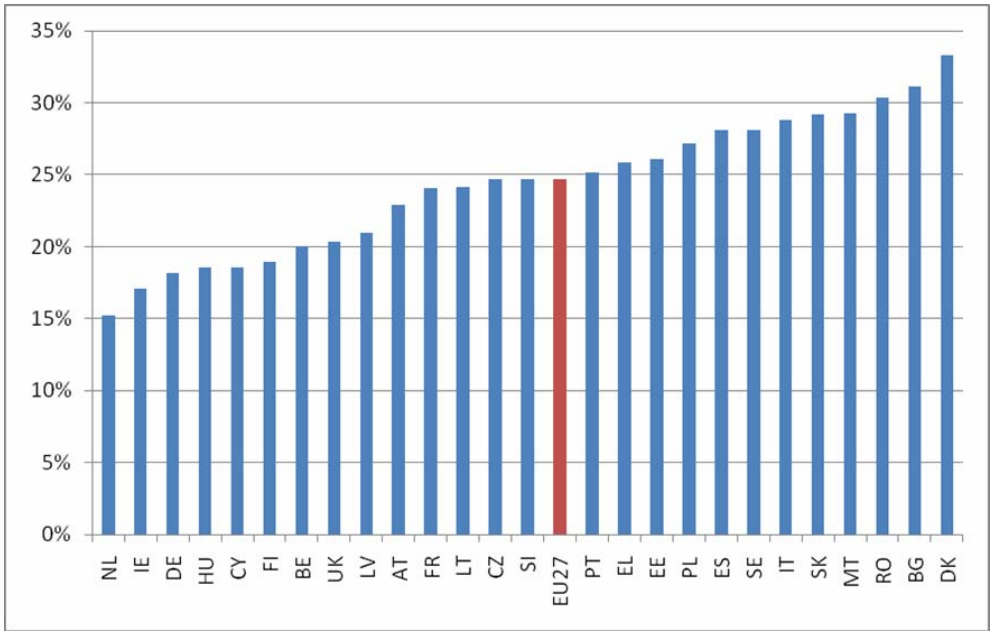
Figure 28: The proportion of female students enrolled in tertiary education (ISCED 5-6) by field of study, 1998 and 2007



Source : Eurostat, own calculations.

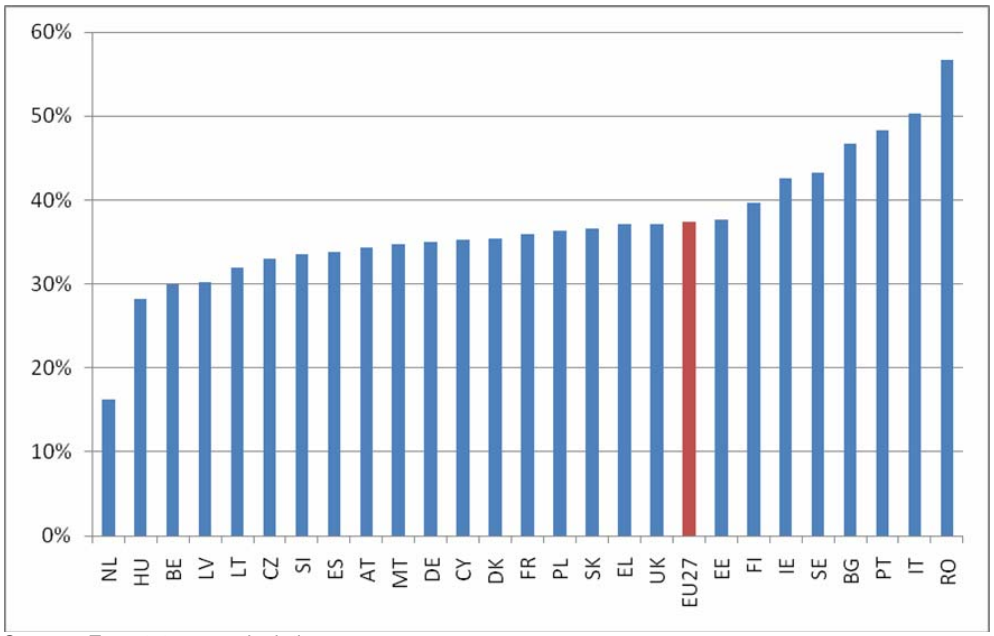
Figures 29 and 30 illustrate how gender segregation across study fields varies across European countries, the two fields where women are generally least well represented are: engineering, manufacturing and construction and science, mathematics and computing. In engineering, manufacturing and construction, the smallest share of female students is observed in the Netherlands (15%) and the largest share in Denmark (33%). In science, mathematics and computing, women are particularly absent in the Netherlands (16%) whereas their proportion exceeds 30% in Romania, Bulgaria and Denmark.

Figure 29: The proportion of female students (ISCED 5-6) in engineering, manufacturing and construction in the EU27 in 2007



Source : Eurostat, own calculations.

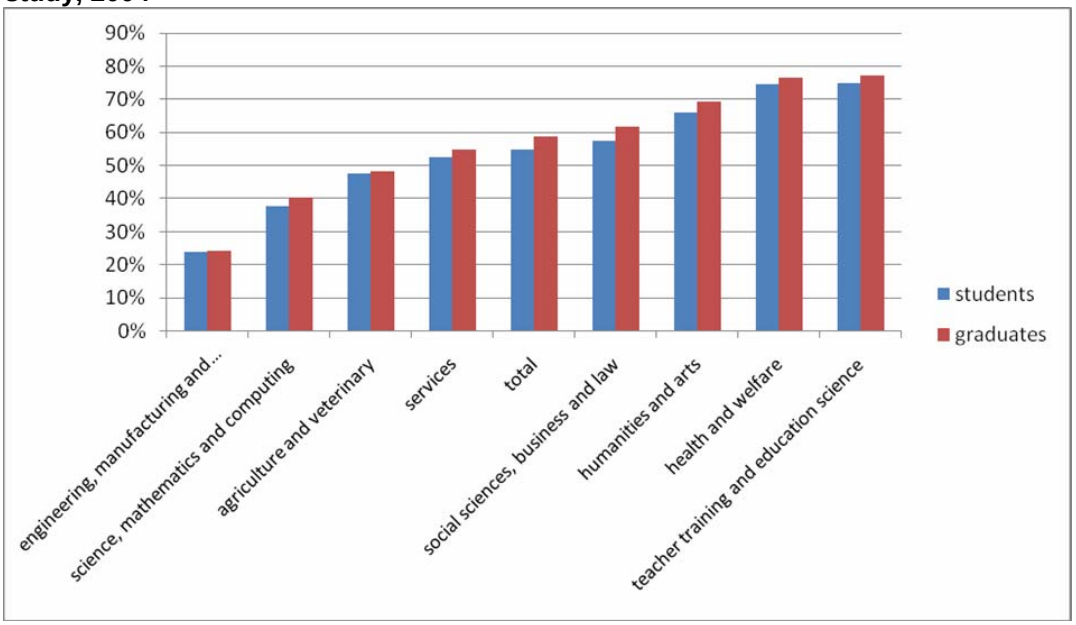
Figure 30: The proportion of female students (ISCED 5-6) in science, mathematics and computing in the EU27 in 2007



Source : Eurostat, own calculations.

A comparison of the number of students and graduates in 2004 shows that women outperform men in all fields of study except for engineering where the share of women among students and graduates is equal (Figure 31). Concerning doctoral graduates, the proportion of women also shows an increase. However, the probability to start a doctoral thesis and to finish it is still higher for men that for women although women are rapidly catching up. Indeed, the data in She Figures 2009, (EC, 2009b) suggest that there will be more female than males holding a PhD in the near future.

Figure 31: The proportion of female students and graduates in tertiary education (ISCED 5-6) by field of study, 2004



Source : Eurostat, own calculations.

Gendered choices and differences within scientific disciplines have been analysed by numerous studies in the Gender and Science database. Among Italian economists, for example, mathematical and econometric modeling pertain more to males, while the study of the history of economics, economic policy, and applications of theory more to women (Addis, 1999). Another example can be found in Croatia where horizontal segregation was noted in medical specialisations in mid-1980s: women physicians tend to specialize more often in the fields considered to be more compatible with their family obligations, such as school medicine or microbiology. Disciplines like surgery, urology and orthopedics were predominantly male (Cerjan-Letica, 1987).

Horizontal segregation has been investigated in Eastern countries by Feber et al. (2004). The authors explain that significant differences emerged between men's and women's choices of field of study during the last decades.

Table 21 shows the evolution of the proportion of female Hungarian students between 1990 and 1999 by field of study. The data show a situation similar to that of most countries.

Table 21: Percentage of women among full-time students by field of study in Hungary

Field of study	1990	1999
Technological sciences	15.7	23.3
Agrarian sciences	33.1	56.3
Veterinary science	18.4	55.5
Medecine and pharmaceutical sciences	53.1	59.7
Healthcare	95.0	92.3
Economics- business	59.0	60.7
Law	53.8	61.4
Liberal arts	72.3	68.6
Natural sciences	41.4	45.6
Teachers training (college)	69.2	70.0
Schoolteacher training	88.6	85.8
Kindergarten attendant	98.4	94.8
Art	53.8	56.7
Theology	20.6	44.2
Other	5.8	20.4
Total	**48.8**	**53.6**
	N=76,601	*N*=171,612

In: Feber et al., 2004, p. 95.

Table 22 can be completed by the data provided by Palasik and Papp (2008) for the year 2000. The authors underline the feminisation of certain fields of study such as pedagogy, specific professions in the medical field like anesthetists, laboratory, school and x-ray doctors, or magistrates within juridical professions. Whereas regarding industrial and construction professions, in spite of a numerical growth in women's presence among the graduates, the growth in their proportion fell short of that of men, therefore women's percentage in these professions decreased. The evolution of the proportion of women across fields of study in Hungary can be observed in the following table. One can see that "*In university basic training, from which the future researchers emerge, the proportion of women is the smallest in the fields of computing, engineering, physical sciences and mathematics in addition to security services. The proportion is also under 50% in the following areas: architecture and building, agriculture and manufacturing and processing. On the other hand the percentage of women is exceptional in the fields of social services, veterinary sciences, humanities, journalism and information management, business administration and life sciences*". (p. 92)

Table 22: The proportion of female undergraduates in higher education according to field of study in Hungary by the ISCED 2 categorisation of all courses (2001–2005)

ISCED fields of science	2001/2002	2002/2003	2003/2004	2004/2005	2004/2005
	Women %	Women %	Women %	Women %	Number of women
Teacher training and education science	70.4	70.2	68.0	69.6	46,376
Arts	56.6	56.9	56.4	57.3	3,213
Humanities	67.2	67.4	67.8	68.8	23,205
Social and behaviourial science	61.4	60.1	61.5	63.1	21,249
Journalism and information management	69.8	70.5	69.1	72.0	11,051
Business and administration	63.8	66.9	66.3	67.9	66,777
Law	57.3	59.0	60.2	59.3	11,186
Life sciences	61.1	62.8	65.4	65.9	1,600
Physical sciences	63.2	37.6	37.1	38.0	1,393
Mathematics and statistics	37.0	39.8	40.3	40.9	514
Computing	25.5	26.9	27.1	23.8	3,312
Engineering sciences	13.0	10.6	9.7	9.2	3,239
Manufacturing and processing	54.6	55.0	53.0	54.0	2646
Architecture and building	36.6	36.0	64.1	35.7	3,734
Agriculture, forestry and fhishery	45.6	45.4	44.7	44.7	5,117
Veterinary	54.1	60.6	65.3	71.8	659
Health	71.7	73.1	75.1	72.8	13,439
Social services	81.6	81.5	81.5	82.7	10,429
Personal services	69.7	71.3	70.1	70.0	11,797
Environmental protection	53.7	53.7	52.8	52.3	3,451
Security services	22.6	33.3	30.8	37.2	2,946
In total	56.1	57.4	57.7	59.1	247,333

Source: OM 2005
In: Palasik and Papp (2008), p. 92.

B. Aptitudes and performance

Van Langen et al. (2006) analyse the variation in gender gaps in mathematics, science, and reading literacy, both across countries and across schools within countries, using the PISA data. "*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) Girls were also found to achieve relatively better in rural as opposed to urban schools. "*That is, the delays of girls with respect to boys in the fields of mathematics and science*

literacy are smaller and their reading advantage larger when they attend a rural school. When the pupils in a school have higher proficiency levels on average, moreover, the relative position of the girls also tends to be more favourable. That is, the mathematics and science delays of girls with respect to boys decrease and the reading advantage of girls over boys increases under such circumstances. The same holds at the level of the country but then for only science: The science delays of girls with respect to boys are smaller in countries where the average levels of science proficiency are higher". (p. 173)

The results of their analyses further showed "*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)

Meelissen and Luyten (2008) investigated the gender gap in mathematics in the Netherlands. The main conclusion of their study is that gender differences related to self-confidence in mathematics were a bigger issue for Dutch Grade 4 students who participated in the survey than were differences related to achievements in mathematics. This study also shows that the lower levels of self-confidence among girls was clearly related to the lower achievements of girls compared with boys. If girls were just as confident as boys, they would perform better. "*Gender accounted for just 0.1% of the variance in mathematics achievement. The differences were considerably larger for beliefs and attitudes. The difference for liking mathematics was twice as large as the difference for achievement (.136 versus .062; see Table 1). Most striking was the disparity with regard to self-confidence. Here, the gender difference was seven and a half times larger than the difference for achievement (.463 versus .062). Even the difference in stereotyped views between boys and girls (.382) was smaller than the gender differences with regard to self-confidence.*
The importance of self-confidence in relation to mathematics became even more apparent when we added this factor to the achievement model as an explaining variable. The analysis showed that among students with a similar level of self-confidence in mathematics, the girls' scores were better than the boys'. However, among students with a similar level of mathematics achievement, the level of self-confidence that girls reported in relation to mathematics was still substantially lower than that reported by the boys. When we considered the variable ''liking mathematics,'' we found that self-confidence accounted for the difference between boys and girls. However, liking mathematics only partly accounted for the gender difference in self-confidence. Cognitive safety in the class also related to self-confidence, but only to a very limited extent in terms of the gender difference.
The interaction effect of stereotyped views with gender seems to be in line with common-sense expectations. For boys, it coincided with a relatively high level of self-confidence, while the effect was in the opposite direction for girls. In other words, those boys who regarded mathematics mainly as a male domain also showed high levels of self-confidence. Girls who shared this opinion were relatively less confident compared to the girls who disagree with the notion that mathematics is a male domain. However, the size of the negative effect for girls was about twice as strong as the positive effect for boys, indicating that boys' self-confidence in mathematics was less dependent on their gender-stereotyped views than was the case for girls' self-confidence in mathematics". (p. 91)

A study by Guiso et al. (2009) analyses gendered math performances. To assess the relative importance of biological and cultural explanations of the gender gap in mathematics (difference between girls' and boys' scores), the authors studied gender differences in math test performances across 40 countries using the data from the 2003 Programme for International Students Assessment (PISA). Girls' math scores are on average 10.5 points lower than boys' - but the results vary by country. The gender gap is reversed in reading: on average girls have reading scores that are on average 32.7 points higher than those of boys. To explore the cultural inputs to these results, countries were classified according to several measures of gender equality (World Economic Forum's 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 expands in more gender-equal societies. In countries with a higher GGI index, girls close the gender gap by becoming better in both maths and reading. In more gender-equal societies, girls perform as well as boys in maths and much better than them in reading.

In Israel, the university admission score is based on a combination of high-school matriculation grades and the score on a standardized admission test. It has been found that male candidates scored better than female ones on the standardized test, while female candidates had higher matriculation grades. Therefore, no difference was found between male and female university admission scores, so that the admission process was found to be unbiased (Azen et al., 2002). The contrary was found in the Czech Republic where there are higher prospects for admission to university studies for men compared with women in most fields of study. Women face discrimination when applying for technical or natural sciences, as they are seen as less cognitively equipped for such a study (Čermáková, 2000, 2002).

Box 7: Examination of Gender Bias in University Admissions

In this Israeli study the admission procedures for university students were examined to see if they are gender biased. The criterion used to measure bias was performance in the first year of university study; the predictors consisted of an admission score, a high school matriculation score, and a standardised test score as well as its component subtest scores. Statistically, bias was defined according to the boundary conditions given in Linn (1984). No gender bias was detected when using the admission score (which is used for selection) as a predictor of first-year performance in the university. Bias in favour of women was found predominantly using school grades as predictor whereas bias against women was found predominantly in using the standardized test scores. It was concluded that the admission score is a valid and unbiased predictor of first-year university performance for the two genders.

Azen , R., Bronner, S. & Gafni, N. 2002, 'Examination of gender bias in university admissions ', *Applied Measurement in Education*, vol. 15, no. 1, pp. 75-94.

C. Roots and explanatory factors

After having drawn a picture of the situation of gender segregation in education on the basis of findings issued from the descriptive work, this section raises the question of the causes and factors explaining gendered educational profiles.

Educational segregation takes its roots at an early age when students attend secondary school. A study even states that knowledge and sex-stereotyped behaviour increases significantly between age 2-3, and so does segregation.

Box 8: Longitudinal study of gender-related cognition and behavior.

Gender schema theory proposes that children's acquisition of gender labels and gender stereotypes leads to gender-congruent behaviour. Most previous studies have been cross-sectional and do not address the temporal relationship between knowledge and behaviour.
The authors conduct a longitudinal study of gender knowledge and sex-typed behaviour across three domains in children tested at 24 and 36 months (N = 56).
The authors find that although both knowledge and sex-typed behaviour increase significantly between 2 and 3 years, there is no systematic pattern of cross-lagged correlations between the two, although some concurrent relationships were present at 24 months.
These results imply that future longitudinal work should focus on younger children using reliable pre-verbal measures of gender knowledge and employing a shorter lag between measurement times. This research is important in order to understand when gender segregation "starts" in order to design effective interventions.

Campbell, A., Shirley, L. & Candy, J. 2002, 'A longitudinal study of gender-related cognition and behaviour', *Developmental Science*, vol. 7, no. 1, pp. 1-9.

Poglia (2004) analyses the distribution of students across university fields of study in order to learn more about the mechanisms and factors influencing women and men students at Swiss universities, particularly in the fields of natural, exact and technical, and social sciences. The study revealed that schools attended before the Matura (the leaving exams young adults usually aged 18 or 19 take at the end of their secondary education) greatly influenced the choice of the field of study: The type C Matura (and perhaps the constellation of subjects that will replace it in the future) was fundamentally decisive in choosing the natural sciences or the exact and technical sciences, but so was the awareness of personal scholastic skills in science, at least partially in relation to the experience of high marks in these fields over the entire school career. In addition, the study emphasized that the choice of study direction was a rather rational process that was especially influenced by the image the students had made of their skills; their interest for the field they were studying; the – quite realistic – perceptions of the professions, their limits, and their possibilities; and also personal values the students considered important.

If attitudes towards science and technology differ between men and women the old assumption about women's lack of interest in computing formulated in the early 1980s has been demolished by research in Norway that found that it is rather the domination of boys and men (than personal fear) that makes technology less accessible for women. Here, the emphasis is on the importance of milieu. Girls were observed to be pushed aside by boys in the computer class, and female students of computing felt marginalized both socially and in their professional interests, compared to the "hard core" field of programming dominated by men (Håpnes, 1992; Verne, 1988).

Box 9: Subject Choice and Occupational Aspirations among Pupils at Girls' Schools

Various studies have found that British girls' curriculum subject preferences and future aspirations have changed and diversified in recent years. Other work has suggested that girls educated in single-sex schools might have a different (perhaps less gender-stereotypical) experience of education in comparison with their contemporaries at co-educational schools. This article draws on a study of the preferences of girls in English single-sex schools to explore these issues of subject choice and occupational aspiration further. It is argued that, like girls in mixed-sex secondary schools, single-sex schoolgirls' subject preferences have become more diverse and less gender-stereotypical than was the case twenty years ago. But where single-sex schoolgirls might have been expected to rate maths and science more highly than their counterparts in mixed-sex schools, the reverse was the case. The findings support the argument that girls are now significantly more academically focused and ambitious for their future occupations than they were twenty years ago. However, the authors argue that a gender dichotomy remains evident in the types of future occupations chosen by girls.

Francis, B., Hutchings, M. & Amelling 2003, 'Subject Choice and Occupational Aspirations among Pupils at Girls' Schools ', *Pedagogy, Culture & Society*, vol. 11, no. 3, pp. 425-442.

The scarcity of women among certain disciplines seems to be more the result of self-selection than of conscious discriminatory practices. From this point of view, girls' anticipations of social norms and of job markets make their choices rational. However it does not prevent them to be influenced by gender roles or stereotypes in their choice of educational field. Boys are also influenced by these stereotypes and cultural patterns.

According to Alaluf et al. (2003a), we are still strongly impregnated by old stereotypes. A lot of research studies have proven that girls are not less gifted than men. The success in school is more a function of the social origin than of any other characteristics. Girls are even performing better at school. However, their choice of orientation does not follow the same tendency as that of boys and they tend to select less "valorized" options or orientations. Boys who pursue a strong mathematical option at the secondary school are concentrated into fields with a strong scientific component while girls who follow the same option are more widely distributed across a range of fields.

The socialization process is consequently very important in the choice of study. Family support is a very important factor in encouraging girls to choose science curricula. Research observed that people from highly educated families graduate at a younger age and more often get better-paid jobs (Silvennoinen, 1992). Children with parents who have a doctor's degree more often start a PHD thesis (Högskoleverket 2006; Leemann, 2002). A German research study concludes that more than career prospects or job security, personal interest, own giftedness and recommendations of primary reference groups like parents, teachers and friends are essential motives for the choice of a study subject (Zwick and Renn, 2000). Teacher-pupil interactions (Ammermueller and Dolton, 2006) in the classroom also play an important role in this respect.

Women also appear to be less self-confident than men; they will then tend to be more modest in their study choice (van Kalles, 1996; Hilden and Munk, 1983). Biology for instance is labelled as an authoritarian discipline with a dominant teaching style, in comparison to lecturers in pedagogy practice teaching concepts which are oriented on autonomy and the ability to give and receive criticism (Schaeper, 1997). However, more recent data from She Figures 2009, (EC, 2009b) show that biology was a female-dominated field. This illustrates that explanations for gender segregation as they have developed over time remain fragile.

Box 10: Access of young women to academic scientific and technical studies

The report examines the conditions of access of young women to the scientific and technology sectors of the university. 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, there are two groups of elements that 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 whether it is a man or a woman. 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, mimeo.

D. Measures and policy actions

Research concerning the measures needed to tackle educational segregation suggests that the earlier actions for improving gender equality are undertaken during the educational path, the more the inequalities at higher levels will be reduced over time. The most common measure proposed is to encourage girls to choose science courses in order to change the image of science and of women scientists. In general, the measures implemented to increase the proportion of women in technology and engineering are reform of the curricula, interdisciplinary study and course programmes and the promotion of female teaching staff and professors.

Gender segregated tuition has been studied in primary school as a way to maintain students' interest in the natural sciences (Sendrup, L. & Frimodt-Møller, I. 2001; Kruse, 1996). It encourages children to experiment with topics that stereotypically are dominated by the opposite sex, i.e. gender stereotypes are broken down. Besides, it could be that girls get more attention from teachers in gender-segregated tuition and tuition benefits from differentiated teaching methods. Thus, gender segregated tuition could turn out relevant for the general success of both boys and girls in the entire educational system. Single sex education in science and engineering can put forth positive learning experiences, increased self-confidence, development of special group solidarity, from growing chagrin regarding a constant

devaluation of women's degree course and of that of all female students to an overacted presentation as a new female elite, and finally to a process of break up and disillusionment (Bund-Länder-Kommission für Bildungsplanung und Forschungsförderung, Bonn (ed.) 2002).

Research in Israel found that in schools that offer a wider choice of study topics, girls tend to choose Biology and Humanities rather than Maths-related subjects, while in schools with less choice the difference in preferences is not as pronounced. This research suggests that the degree of choice in secondary school is correlated with educational segregation in higher education (Ayalon, 2002).

The Dutch country report (Van der Brink, 2009, p.2) states that "*although some academic disciplines still have an under-representation, some disciplines face an over-representation of female students, for instance in medicine and psychology. As far as this results from positive selection—when female students are better qualified and more motivated for an academic career than male students—we can face the future with confidence. However, as far as the over-representation of women in the PhD student category results from negative selection—when male students prefer the better career prospects outside the universities—there is reason for concern*".

3.4.1.2. Labour market

A. Description of occupational and sectoral segregation

Studies that concern gender horizontal segregation in the labour market present very different situations. This is not surprising since the structure of the labour market varies strongly across countries. The place and functioning of scientific institutions also differ strongly from one country to another. This explains the lack of homogeneity in the research results.

A general remark is that horizontal segregation in the labour market (the distribution of researchers and scientists by scientific fields) shows the same tendencies observed concerning educational segregation (the distribution of students by scientific field). At the level of (scientific and research) occupations the reality of traditional "male" fields, where the proportion of men is higher than women and "female" fields where the proportion of women is higher than men is reflected. In Switzerland, for example, there is a persisting under-representation of women in certain areas of science and technology in higher education, namely in mechanical and electrical engineering, in IT and in physics (Gilbert, 2005).

Several studies investigate the choice of specialization in the medical career in order to underline possible differences between men and women. According to Jensen (1995), women are more present in less prestigious research and working fields like paediatrics or gynaecology, while men dominate surgery and internal medicine. Field and Lennox (1996) argue that women suffer discrimination because of their gender in certain specialties. However, a Danish study showed that women were as likely as men to start their career in surgery and internal medicine. The problem is that they do not complete specialist training in these fields (Gjerberg, 2002). Note that this Danish study (2002) is much more recent than that by Jensen (1995). She Figures 2009, (EC, 2009b) has shown that women's proportion in fields such as medicine has grown markedly over recent years.

Box 11: Gender similarities in doctors' preferences and gender differences in final specialization

This article is based on a career history study of gender differences and similarities in recruitment to and transitions between specialities among Norwegian doctors. A questionnaire on career and family history was sent to all Norwegian doctors authorised in 1980-1983. Descriptive statistics and logistic regression were used to describe and analyse completion of specialisation in the specialty in which they started their career. Survival analysis was used to analyse transitions between medical specialities. The findings clearly contradict the idea that the low proportion of women in male dominated areas of medicine reflects women's lack of interest in specialities like surgery and internal medicine. Women were as likely as men to start their career in these fields. The problem is their not completing specialist training. A far higher proportion of men than women completed their specialist training in surgery. The reasons for this are complex. Heavy work loads 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 postpone having their first child compared to women in other medical specialities. However, the fact that some women change from surgery to gynaecology and obstetrics, a specialty which to a considerable extent are comparable with surgery with regard to duty and work loads, indicate that structural barriers in combining childcare and a hospital career do not fully explain the flux of women. The possible existence of other closure mechanisms in surgery, as indicated by some doctors in this and in other studies, has to be further explored.

Gjerberg, E. 2002, 'Gender similarities in doctors' preferences: and gender differences in final specialisation', *Social science & medicine*, vol. 54, no. 4, pp. 591-605

Segregation can also be approached by looking at the representation of women in science and research professions by sector. In this regard, Rehmann (2004) gives information concerning the Swiss case. He finds that the participation of women in education and research is increasing, but women remain strongly under-represented. Concerning the private sector, the percentage of women researchers is lowest with 16.5%. The percentage of women in management positions in these companies is approximately 8%. It is however worth noting that official data collection methods are not as fine-tuned as those of universities. It is also estimated that women in the private sector earn at least 20% less than men in the same position. The report also mentions that there are individual companies which implement equal opportunity measures. Particularly the large chemical and pharmaceutical firms, that need intact and innovative research teams, place a high value on gender equality. In addition they are also striving to enlarge the participation of women at the management level and in research.

Feber et al. (2004) investigated the segregation in the Hungarian labour market and reported that: "*In 1998 between 23,000 and 24,000 people worked in scientific jobs in Hungary, down from more than 30,000 in 1990. During the same years, however, the percentage of women in these jobs grew from 28 percent to 34 percent, presumably because of less financial support for research, low earnings in such positions, and the generally declining prestige of careers in research."*

According to Palasik and Papp (2008), despite the increase in the number of women researchers in Hungary between 1990 and 2005, the smallest number of women in higher-education institutions continues to be in the field of engineering. The increase in female researchers has not been identical according to the sector considered. Whilst in the budgetary institutions and in the institutions of higher education their proportion has increased compared to the 1990 data, it has fallen by 2.1% in the field of industrial research (Table 23). Generally speaking, the social standing of research careers has gradually decreased over the past 15 years. Several talented research workers moved to other fields or abroad, and the government commitment in terms of R&D subsidies appeared to be ineffectual. They also underline a strong correlation between feminised areas and lower earnings.

The studies from Feber et al. (2004) and Palasik and Papp (2008) address two other important issues: the segregation between research and other professions and the feminisation of research because of the devaluation of the research profession.

Table 23: The distribution of researchers by sector in Hungary

	Budgetary institutions			Higher education			Private sector			In total		
	N total	N wmn	% wmn	N total	N wmn	% wmn	N total	N wmn	% wmn	N total	N wmn	% wmn
Natural Sciences	2,163	624	28.8	2,552	744	29.2	156	48	30.8	4,871	1,416	29.1
Engineering and technology	581	117	20.1	3,076	549	17.8	5282	1,115	21.1	8,939	1,781	19.9
Medical sciences	631	359	56.9	3,378	1,475	43.7	246	96	39	4,255	1,930	45.4
Agricultural sciences	756	340	45	942	307	32.6	266	69	25.9	1,964	716	36.5
Social sciences	722	242	33.5	3,936	1,456	37	150	51	34	4,808	1,749	36.4
Humanities	1,360	689	50.7	5,202	2,448	47.1	8	2	25	6,570	3,139	47.8
In total	6,213	2,371	38.2	19,086	6,979	36.6	6,108	1,381	22.6	31,407	10,731	34.2

Source: KSH 2006a, numerical data
In: Palasik and Papp, 2008, p. 100.

While overall and in higher education the proportion of female researchers is the highest in the field of humanities, in budgetary institutions and in the private sector, their proportion is the highest in medical sciences. In the private sector; most researchers are employed in the field of engineering and technology, and this field also has the highest number of women. However, the proportion of women compared with men is the lowest in engineering and technology within the private sector as well as in the other sectors and in total. The other discipline where the proportion of women is the highest in the private sector are natural sciences. *"The aggregated dissimilarity index, which shows the proportion of researchers who should go to another field in order to equalise the male-female ratio in all fields, amounts to 23%. This index is 18% for higher education, 24% for budgetary institutions and 8% for the private sector"*. (p. 100)

Palasik and Papp (2008) also investigate the link between the presence of women in a field and the level of expenditures in this field. "*In the case of budgetary institutions, the proportion of women is the highest in the fields of medical sciences and humanities, and the expenditures are the lowest in natural sciences and humanities. In the higher education sector, women's percentage is low and the expenditures are high in engineering and technology (the lowest proportion and the second highest rate of expenditures), and we find the opposite to be true in the field of humanities. The proportion of women is also high in medical sciences although the expenditures do not seem too low compared to other fields (the proportional value is the second highest while the expenditures are the third lowest). The expenditures are the highest in agricultural sciences, however, the proportion of women is not exceptional there. In the research positions of the private sector, the proportion of women is high and the expenditures are at a low level in natural sciences (the second highest proportional value and the second smallest expenditure). The proportion of women is the lowest in engineering and technology which hold second place in terms of expenditures. The expenditures are the lowest in humanities, but the proportion of women is far from the highest. Both the proportion of women and the expenditures are highest in the field of medical sciences (p. 104).*

The authors also show that vertical segregation worsened between 1999 and 2005[1]. "*This drastic fall of research headcount can be explained by several factors. Firstly there were considerable cutbacks both in the academic sector and in the sector of research institutions after the change of regime and in addition to this most of the research institutions of large state enterprises were eliminated. Secondly, the earnings of scientific researchers remained at a low level and the better earning conditions available in the private sector of the economy tempted men away from the 'citadels of science'. This process affects men more than women because women find it much harder to reconcile the work hours and intensity expected in the private sector with their family and household duties, i.e. with the so-called traditional female roles. Thus the decrease in the number of males in scientific research can be explained by the phenomenon […] claiming that in our region men gather in the more profitable professions, and as the increasing number of researchers does not mean a simultaneous remarkable increase in the GDP -proportional R&D expenditures, it directly follows that men have not returned to these professions yet. Developments in the near future shall reveal whether this advancement proves stable or not*". (p. 97)

The authors' findings concerning the scientific career are as follows: "*the scissors seem to have been closing over the past five years, yet it is uncertain whether this trend is to continue, cease or turn around. Based on examples from other fields it can be expected that if there is more money invested in research, providing better perspectives for research careers, men will return to this field and some of the women will once again be squeezed out of this profession. One of the reasons behind the much slower career building of women is the fact that a strong social belief persists that career success is primarily, 'men's business'. The approach of society is basically male-centric, men, but in many cases women themselves, being unwilling to accept a female superior. The real reason is likely to be found somewhere else, however; career progression is blocked by the female roles: motherhood, household chores and the duties as come along with them, the burden of which cannot be put on the other members of the family to the same extent as would be acceptable in the case of male graduates. Maternity benefit is generally used by women, apart from a few men, although men are also allowed to do so by law. Holding the family together is always the task of women, and maintenance of the household has still not become much easier despite the development of household technology and the widening range of pre-prepared foods, as their operation and preparation also requires time and money. Furthermore, the incomes only allow a small number of people to pay for services that speed up the completion of housework and the provision of the family."* The report finally explains that the question of introducing programmes for supporting the career and equal opportunities of women with the aim of increasing women's proportion in those fields where female researchers are under-represented has not yet been considered seriously in Hungary.

Stöckelová and Linková (2008) present the situation for the Czech Republic. As it was observed in other countries, women are concentrated in fields such as social sciences, pedagogy, medicine and biology. Moreover the pay distribution reflects this segregation. Fields where women are over-represented are considered to be less valuable or less demanding than those where men predominate. Fields with a lower number of women are strongly theoretical and have a high status. Table 24 presents data on horizontal segregation. Women constitute 32.6 % (as of 31 December 2005) of employees in research and development. There is a particular high percentage of women in the medical sciences, humanities, the social and the agricultural sciences, and low numbers of women in the technical sciences.

[1] In 1999, only 13.4% of professors, 29.5% of university and college associate professors, 40.9% of assistant professors and 46.6% of assistant lecturers were women. Compared to these figures, the situation worsened by 2005 when female employees represented 11.94% of professors, 26.83% of associate professors, and 35.73% of assistant lecturers and professors.

Table 24: R&D employees in the Czech Republic, by discipline

	2000			2004			2005		
discipline	total	of wich women	% women	total	of wich women	% of women	total	Of which women	% of women
Natural	4,429	1,288	29.1	4,822	1,252	26.0	6,483	1,714	23.9
Technical	6,202	895	14.4	7,083	980	13.8	10,178	1,427	14
Medical	909	393	43.2	1,328	596	44.9	2,483	1,160	46.7
Agricultural	929	400	43.1	935	358	38.3	1,462	583	39.9
Social	311	120	38.6	1,115	453	40.6	1,929	803	41.6
Humanities	1,072	455	42.4	1,017	413	40.6	1,634	662	40.5
total	**13,852**	**3,551**	**25.6**	**16,300**	**4,052**	**24.9**	**24,169**	**6,349**	**26.3**

Source: Czech Statistics Office. Ukazatele výzkumu a vývoje 2005; In Stöckelová and Linková 2008. p. 77.

Giannini and De Feo (2008) show, for Italy, that academic women are concentrated in disciplines that are considered to be "weak", i.e. not crucial to the degree and therefore not strictly mandatory, on the basis of the organisational logics legitimated by recent reforms. The results of their empirical research supports the finding that there is a connection between sex and chosen discipline, with respect to choice and to commitment.

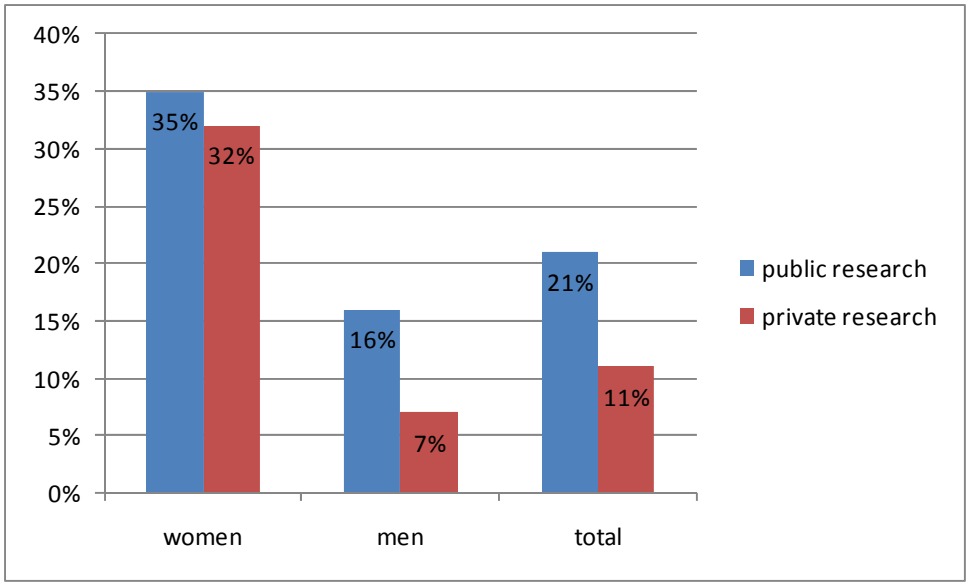
Ntermanakis (2005) investigates the Greek case. By using the indicators ID (Index of Dissimilarity) and IS (Index of Segregation) and statistical data drawn from different sources, the study attempts to illustrate the changes in horizontal segregation in various financial fields and professional groups during the period 1993-2003. According to the indicator IS, the phenomenon of horizontal segregation intensified over the years (from 29.5% in 1993 to 33.6% in 2003). Despite women's increased participation in certain professional groups, they had a limited presence in physical and technology sciences and top managerial positions, which doesn't exceed 50% in large organisations, with the exception of public administration. Another finding was that age was inversely proportional to the magnitude of professional segregation, with the highest ratio observed in the age category 15-29. The study also referred to horizontal segregation in all the administrative departments of the country and, despite the differences between them, the conclusion was that women's participation in the labour market is indirectly proportional to the extent of segregation. It stresses the fact that segregation in the labour market may be due to educational segregation. Despite the rise in women's participation in tertiary education, there was no significant reduction in educational segregation. Women choose more traditionally feminine scientific fields of study compared to men who select science. This paper contributes to increasing our understanding of the magnitude of horizontal segregation, whilst underlining the risks of oversimplifying the real situation.

As in many countries, in Greece, in terms of academic qualifications, male researchers more often have a PhD, while women an undergraduate degree or a postgraduate degree (Maratou Alipranti, et al., 2001).

The French Ministry of Research carried out a study in 2002 on women in a scientific career. The main findings from this report are that there are more women researchers in the public sector (30%) than in the private sector (19%). Two thirds of women researchers work in the public sector. The proportion of women

also varies according to field of research. Physics and mathematics show the lowest proportions of women. In the Parisian region women's situation is more favourable than in rural regions. Since 1992, the number of women in research occupations grew at a faster rythm than that of men and also than female employment in the labour market in general. This is observed in both the public and private sector (Figure 32).

Figure 32: Growth in research jobs between 1992 and 1999



Source: Ministère de la Recherche, 2002, p. 7.

In general, the employment growth rate is higher for women researchers (4.2%) than on average for the total of researchers (1.5%). One can speak of a general trend, although the report does mention that men are more easily promoted than women and this is especially true for young men. There are important differences across institutions and disciplines. Regarding promotion and evaluation, in France, the institution-based culture is stronger than the disciplinary culture. The proportion of women research directors is 25% in public research institutions. In universities this proportion is 7 percentage points lower (18%). Across all disciplines, promotion practices are less favourable towards women in universities. However, important differences exist between public research institutons.

In Austria, it appears that the share of women increased especially in non-university research institutions (Kreetz, 2004). In this country, university and non-university research are two relatively separate labour market sectors with very different working conditions for scientists and with hardly any institutionalized transfer possibilities from one sector to the other.

Box 12: Expertise and existential securing instead of advancement - female scientists in non-university research in Austria

Ulrike Papouschek presents the main findings of the study "Arbeitsmarkt, Arbeitsbedingungen und Berufsbiographien von Wissenschafterinnen in der außeruniversitären Forschung in Österreich" (labour market, working conditions and professional biographies of female scientists in the non-university research in Austria). The author describes, in her survey, as a first step, the change in the hitherto largely unknown situation of non-university female scientists in Austria. Therefore the fundamental tension between the economic approach and scientific activity is identified with a central structural element. This segment of the labour market is still far from reaching gender equality. Female scientists are over-represented among career starters and among the project-orientated, and concentrated in the not subsidized non-university research segment. Women also have the least secure employment conditions. At the same time the few controlling positions in non-university research are often over-average held by men. The implementation of political equalization and political research measures appears not nearly sufficient.

Papouschek, U. 2004, 'Expertise und existenzielle Absicherung statt Aufstieg - Wissenschafterinnen in der außeruniversitären Forschung in Österreich' in E. Appelt, ed*. Karrierenschere*, LIT Verlag, Vienna, pp. 143-160.

B. Roots and explanatory factors

Much research has been carried out on the period of transition from school to work in order to explain sectoral segregation of women in science and research.

In Belgium, it appears that for ten years the proportion of women who have a degree in applied science who wants to work in research is rising (Alaluf, 2002). In the same country, one especially observes a rise in the percentage of female scientific and academic staff in faculties of human sciences. This increase is more dramatic in human sciences than in applied sciences and informatics (Meulders and de Henau, 2003). The same phenomenon has been observed in Denmark (Dons Jensen, 2009).

In many countries, it has been observed that after completing their degree, a smaller proportion of women than men choose a research career. This is especially true for particularly feminized studies. The model for scientific career building remains a “male career model” (Fernández Vargas, 2002; Llaguno *et al.* 2002).

Stolte-Heiskanen (1991) examines to what extent the chance criterion of gender plays a role in the position of women in Finnish science. For more than two decades the proportion of women university students has been somewhat over 50 per cent and their share among post-graduate students rose to 41 per cent in 1986. But despite the exceptionally high rate of women’s participation in higher education, their distribution according to field of study does not differ from other Western European countries. The universally noted phenomenon of gender differences in the fields of study is also evident in Finland. Also the scarcity of women among natural and technical science students seems to be more the result of self-selection than of conscious discriminatory practices in the higher education system. The percentage of women in all research posts is smallest in engineering and technical sciences and highest in the social and natural sciences. Women in science are not only numerically under-represented but they also experience greater difficulties in embarking on a scientific career. One of the explanations for the relative absence of women from science is that socialisation processes reproducing traditional gender roles result in the self selective avoidance of scientific careers by women. The greatest pressure for achievement and embarking on a scientific career coincides with the establishment of home and the family: between ages of twenty-five and thirty-five. This probably explains why women are older than men at each step of the conventional career pattern. Data from career histories of women also reveal condescending attitudes towards women’s scientific abilities by their male colleagues. In the social arena of science too, it is evident that women have a very limited access to structures of scientific power and prestige.

A study from Abele and Stief (2004) found that, attitudes, interests, self-concepts, and study performance predicted occupational expectancies and goals. Objective indicators of occupational success are predicted by occupational self-efficacy and occupational goals. Women do not differ from men with respect to career relevant psychological variables but are less likely to successfully enter the career. Therefore, in objective terms, gender discrimination matters whilst subjectively assessed career success appears to be influenced by self-efficacy, goals, and study performance, but not by gender.

Balahur (2008) also studied the motivations of women to choose education and careers in science and technology. The findings of her research prove that women having selected a scientific career have a high level of self-efficacy nurtured by persistent accomplishments in math and technological disciplines throughout the educational cycles– presupposed by an early diversity of cognitive interests and the pleasure to play with and watch machinery, and supported, at key moments, by parents –both fathers and mothers- and their teachers. Their 'profile' (the maximal profile) is described in this publication.

Schoon et al. (2007) also underline the importance of socialisation in career choice. The authors intend to address individual as well as family and school related influences on uptake of science, engineering, technology and health related careers. Drawing on data collected for two British birth cohorts: the 1958 National Child Development Study and the 1970 British Cohort Study, a developmental contextual model of career development is tested, comparing the experiences of over 17,000 men and women during the transition from school to work. The findings suggest that there is a persisting gender imbalance both in terms of aspirations and occupational attainment. Interest and attachment to a science related career are formed early in life, often by the end of primary education. School experiences, in particular, are crucial in attracting young people to a career in science.

According to Prpić (2004), mainly women of the upper classes enter the scientific milieu. In Israel, little or no correlation was found between women's occupational status and the sibling order or the number of offspring (Rom-Rivit and Schkolnik, Israel, 2009).

It is worth mentioning the research on career choice that focuses on the field of technology. According to Thaler (2006a), technology design is connected with power and influence as a result women are still routinely excluded from this area. This publication discusses psychological constructs, the Stereotype Threat Effect, as well as gender-specific educational cognitions and gender stereotypes. The close association of technology and maleness and the devaluation of women's technological achievements at the same time are shown as reasons for perpetuating myths (women's technological adverseness and distance) thus hindering women's progress in these areas. The author's main thesis is that universities' dual study courses in applied sciences support female future engineers because students crucially attain work experience thereby bypassing the obstacle of difficult career entry. The first dual study courses in Austria are compared with several study courses in Germany and Austria to analyze this thesis. The survey has shown that the duality of study courses is not however a sufficient support mechanism by itself. Companies' selection procedures of students and the sexism, which still exists in these companies however still act as powerful obstacles hindering female advancement. Interdisciplinary, application-oriented study courses and female (technology) lectures are conducive to achieving a career as a female engineer. Furthermore, a real equality in the company must be experienced for female engineers to have a successful successful professional career.

Miller et al. (2004) investigated the theories of occupational segregation and career choice. The areas chosen for this study are amongst the most strongly segregated: construction, engineering, plumbing, and Information and Communication Technology (ICT) (all male-dominated), and childcare (female-dominated). The statistical analysis clearly demonstrates the extent of gender segregation in employment within these five sectors, although there were some variations between the sectors; employment in ICT is clearly more gender balanced than in the other four sectors.

"*Theories that attempt to account for the establishment and maintenance of segregation include those based on individual differences, including human capital theory; those that are based on ideas of discrimination by employers, including labour market discrimination and rational bias theories; and those*

that take as their central premise, the notion of systemic barriers within organisations, including intergroup and dual labour theories. While no one theory accounts single-handedly for the establishment and continuance of gender segregation, together they help to make sense of these employment phenomena. There has been relatively little empirical research to test these theories at organisational level. There are, therefore, a number of influences which affect occupational segregation and the research shows that these are mutually reinforcing. Decisions made by individuals certainly contribute to the perpetuation of occupational segregation, but perceived occupational segregation in turn influences individuals' choices. […] Occupational segregation remains one of the strongest influences on young people's choice of career, with individuals typically preferring those occupations in which they see their own gender represented. However, this is not a static process; there is evidence that girls (but to a lesser extent, boys) become willing to consider a wider choice of occupations as they become older. Unsurprisingly, ability, attitudes and interest all influence career choice, but attitudes and interest have a stronger influence on job choice than ability. Parental attitudes continue to have a significant impact on the career decisions of young people. This is particularly the case amongst some minority ethnic communities. Parents influence decisions both directly, through their views on appropriate jobs, and indirectly, through their influence on the development of young people's attitudes to school subjects. The teaching style adopted in schools is a further factor which influences the perception of school subjects, particularly the sciences. The advice and guidance offered to young people also affects this process but research suggests that careers advisors may not challenge career stereotypes and see this role as outside their area of responsibility.
There have been a raft of initiatives aimed at increasing uptake of the sciences by girls and the need for improved advice and information is identified as a key issue affecting attitudes towards science careers. Image too is an issue affecting recruitment to some sectors - most notably science, engineering, IT, construction and plumbing - that could be addressed by improving the information made available to young people.
The ability of the qualification to help a young person enter their chosen occupation is a key factor influencing initial choice of qualification, while the perceived rewards of different jobs are, perhaps unsurprisingly, an influence on career choice. However, young women and men are attracted by different aspects of various jobs, and pay is not necessarily the strongest influence. Interest is again found to be a key consideration." (pp. iV-V)

Wachter (2003) studied the same topic. According to this author, women appear to play only a minor role in technology design and technology politics. It is not women's deficits that drive them away from engineering but patriarchally shaped structures and preconditions of teaching and working climate, content and context in technology fields. Higher education institutions and companies are thus faced with the challenge of adapting their environment and content of training and working to meet women's needs.

The perception of the academic career is also an important factor determining women's decision to enter such a career. Two major factors are social attitudes concerning the standard of sufficient education for a woman, and how science is associated with a female career (Zvinkliene, 2003). A Danish study (Voldgaard, 2005) proved that academic scientific and research work requires will, confidence and obstinacy. The disadvantages of a research occupation stated by women are: job insecurity, the demand for mobility, the working environment, the constant pressure to perform, low wages, loneliness, a lack of role models, and poor networks. It also shows that women have lower confidence than men, and that men are more strategic than women, choosing research areas with a lot of career potential, making themselves visible, and putting themselves in line for positions. The consequence is that many female potential researchers become teachers in upper secondary school instead.

Boys are also less likely than girls to opt for a job traditionally held by the opposite sex (Beck et al. 2006).

One can underline specific characteristics concerning the Eastern countries. The historical background in these countries plays an important role in the explanation of the position of women in scientific professions. During the 1970s and 1980s, the percentage of women scientists and engineers was considerably higher than it was in Western Europe. According to the Lithuanian country report (Reingarde 2009), the importance of education in the Soviet past has led to the emergence of a considerable proportion of highly-qualified women, active in all public spheres and notably in science. The transition period has led to the restructuring of research systems in the Central and Eastern European countries and

has generally been characterised by a sharp decline in funding allocated to science, a decrease of the research population, in changes of formal and informal requirements for scientific productivity, and in numerous reforms of the legal basis and institutional structures of the Lithuanian science and education system. Even though these changes affected male and female scientists equally, the consequences of the transition have left women scientists in a more vulnerable situation.

C. Measures and policy actions

In order to reduce segregation, a number of practical interventions are possible e.g. mentoring/coaching, support with funding/grant applications. However, some research conveys a more pessimistic view. Powell and Dainty, (2006) for example, argue that women change their behaviour to fit the culture within which they work so that the critical mass of women entering masculine employment areas will not automatically bring a change in work cultures, and isolation will persist.

In Germany, researchers argued that the "egalitarian gender-reflexive culture" in which even the best forms of gender symmetry into management can be seen, remains rather an exception. In many companies a "myth of equality" emerged, which helps tabooing existing gender asymmetries. A formal level of gender equality is not a guarantee for people behaving in gender liberating ways (Matthies, 2005). Despite improvements the gender equality work is still moving forward very slowly, whilst a few of the measures have even been met with resistance (Gschwandtne et al. (eds.), 2002). The request for equality has in some cases been perceived as a request from the outside and not in harmony with academic criteria for evaluating scientific activity (The Norwegian Research Council, Division for strategic priorities 2002).

3.4.2. Vertical segregation

3.4.2.1. Higher education

A. Description of the situation

Many studies report on gender vertical segregation in academia. The proportion of women decreases along the academic hierarchy everywhere in Europe. The increase in the proportion of women graduates is not followed by an increase in the proportion of women in the higher positions in academia. Women's educational advancement had not led to a corresponding increase in the share of women in positions higher up the academic hierarchy. The number of women in teaching and research positions grows very slowly and in some cases no progressions are observed. In Denmark, for example, women's share of scientific staff has remained almost stagnant while among master graduates women's share increased in the same period. However there are some differences across scientific disciplines (de Coninck-Smith, 2003).

The percentage of women among full professors at Danish universities between 1976 and 2003 is reported by Langberg (2006). It gives an idea of the evolution of vertical segregation across time. The percentage of women among full professors at Danish universities increased from roughly 3% in 1976 to slightly more than10% in 2003. The author also 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).*

Generally speaking, female academic staff are found in the lower positions of the academic hierarchy. One can speak about a higher drop-out rate for women as they advance up the academic career. The gradual disappearance of women starts at the postgraduate and doctoral level. Most women PhD students are on a career path leading out of academia. The difficulty for women to rise in the hierarchy is particularly observed for the two higher ranks of the hierarchy (glass ceiling effect). Advancement stalls when women reach senior positions.

The representation of women is even lower among decision-making bodies and in high-responsibility occupations. Men are overrepresented in these bodies. The existence of a "Mathew effect" (the cumulative advantage/disadvantage of educational factors) indicates that initial differences are strengthened throughout the professional career of women and men (de Henau and Meulders, 2003; Cerjan-Letica, 1987).

Concerning the Eastern countries, their specific history and how it affects segregation have been related by Blagojevic et al (2003). *"Despite all the propaganda on gender equality and the growing professional skills in women, and despite attempts of a non-sexist education, the horizontal and vertical segregation between the two sexes were not lessening, but rather deepening. The labour market was segregated into better paid male and worse paid female areas and despite the fact that more and more women were entering highly qualified professions, it was not mirrored in leading positions. Though this phenomenon has been noticed by Western sociologists in Western countries as well, there was an important difference: in communist countries, the existing glass ceiling was not reflected on, named or criticised by women. Neither was it a theme in the social sciences. As was repeatedly stated by the members of the Enwise Expert Group, namely the up to now persisting lack of gender awareness in the majority of women themselves, including women in science, has turned out to become the major breaking factor to women's career advancement: in terms of career limits being accepted as a natural consequence of their dual role, and in terms of very low sensitivity to unequal treatment"* (p.26). The author also explains that "*horizontal segregation of whole segments of the labour market has been reproduced in the transition period for new reasons: the segments, which were feminised under communism, now remained part of the economically poorer state sector (schools of all levels, health care etc.). And again, this means that women keep their employment (competition is not very intense in these sectors, for men had left for financially more attractive areas), but under conditions that can be characterised as exploitative and under-evaluating their capacities and skills. Needless to add that, though women keep working hard in the professional sphere, they are nonetheless, due to their position of being the second breadwinner in most partnerships, expected to accomplish the duties of parenthood not usually expected of their male colleagues*". (p. 32).

A large part of the report investigates the vertical segregation in academia among those countries. Indeed, as well as in any of the other European countries, vertical segregation is strikingly present. "*Although women constitute a significant proportion of graduates of different schools of HE as well as occupying a significant proportion among the university staff, the ones with a successful university career are much fewer. Additionally, career development is also strongly dependent on the field of study. At the end of the transitional period, a gender vertical segregation in HE has to be underlined*" (p. 58). This can be observed in Table 25.

Table 25: Share of women from the Enwise countries in HE positions at the end of the transition period (1999)

Country	Full professors	Associate professors	Associate professors	Lecturers
Bulgaria	16.4%	30.7%	44.4%	56.5%
Czech Republic	7.2%	20.0%	41.6%	56.4%
Estonia	16.5%	31.6%	50.9%	68.0%
Hungary	11.6%	33.0%	40.0%	Unknown
Latvia	18.0%	40.0%	43.0%	68.0%
Lithuania	11.6%	33.1%	*	Unknown
Poland	15.5%	21.7%	20.9%	38.8%
Romania**	10.2%	32.0%	45.0%	Unknown
Slovak Republic	8.0%	25.0%	48.0%	Unknown
Slovenia	10.0%	15.0%	20.0%	Unknown

Source: Enwise Expert Group- Working documents 2003 and WIS database
Notes:
* in Lituania, the title Docent corresponds to both Western Associate & Assistant professors
** taking into account only 10 of the main state universities in Romania
In: Blagojevic et al , 2003, p. 58.

In most of the countries in the region there is generally high inclusion of women into all scientific fields and there is a trend towards an increase in their participation. Specific information is given concerning the evolution of vertical segregation in Slovenia where women's ability to influence decision-making appears to have improved gradually over the last decade. In 1993 there were only 4% women among the fellows of the Council for Science and Technology, while in 2001 they were 17.1%. In the Slovenian National Scientific Research Council, the presence of women has also risen from 5.9% in 1993 to 30% in 2001. The same positive evolution was also observed in Hungary (Feber et al., 2004). In this country the evolution appears to be more pronounced for the higher grades (professor and assistant professor) than for the lower academic grades.

In Poland, female academics have increasingly been promoted within the academic structures. After Finland and Portugal, Poland has become the country of the European Union with the highest share of female professors (Siemieńska 2007).

A Dutch study (Van Engen et al. 2008) shows that, female academia suffer from lower wages and higher job insecurity (female academics more often have fixed term contracts than male academics).

Vertical segregation varies across disciplines. The highest drop-out rates are observed in the most female-dominated subject areas (Van den Brink, 2009; Meulders and de Henau, 2003). In other words, vertical segregation is higher in the most female-dominated areas. Even in traditionally female dominated departments, leadership positions are held by male professors (Vosniadou and Vaiou, 2006). Croatian researchers have shown that women are underrepresented at the higher levels of appointment in academic medicine despite the so-called feminization of the study field (Đanić, et al. 2003).

In Turkey, where women have high rates of participation in academia, segregation nevertheless exists (Acar, 1998; Ural, 2001). In the report from Palasik and Papp (2008), one can find information on the situation in Turkey and precisely at the Istanbul Technical University. "*There is no segregation between male and female academics in terms of taking part in all university functions and activities. However, there has always been a kind of hidden approach towards the leadership of female academics at the university. When the leader is female she has a tendency to increase female participation at top level of administration across the university*". However, the report also mentions that neither male nor female rectors have been able to create a rule for positive action towards female academics throughout the years.

Majcher (2007) carried out a comparison of women's scientific careers in Germany and in Poland: "*there are also striking differences that are either related to the status of women in society or attached to the recruitment procedures in academia, which in Germany are even more competitive than in Poland because up until recently career development in a "tenure-track" fashion was unknown in Germany. The*

results of the comparison provide a differentiated picture of how German and Polish female academics manage to combine work and family duties. Although women in academia face significant problems in both countries, a university career seems to be less risky and thus more women-friendly in Poland than in Germany. First and foremost, as the author underlines, the bottleneck of attaining a secured and life-long position is very narrow in Germany. Whereas in Poland scientists are promoted within their university, starting an academic career is quite risky in Germany" (p. 36).

B. Causes and explanatory factors

Many studies refer to this phenomenon as the "leaking pipeline". Why is it more difficult for women to access higher positions in academia?

Researchers have proven that women meet more barriers in academia than men do thereby differentially affecting the possibilities of career development for men and women. The organizational culture of the university institution appears to be the major factor explaining vertical segregation. The academic world has been subject to much criticism for reproducing traditional structures and patterns, which support masculine domination, whether regarding recruitment procedures or the organisation of research work with long working hours. It is especially at the rank of professors and full professors in which the academic male culture remains particularly embedded. Structural as well as cultural barriers are indentified.

Box 13: Assessment of the Participation of Women in Science, Engineering and Technology and UCC

An Irish study, commissioned by University College Cork, was undertaken during the summer/autumn of 2005. The project comprised an analysis of current numbers of female staff in the various categories employed in SET in the University College Cork (Ireland). This study is a very interesting analysis since it provides a deep understanding of the factors that causes vertical segregation. It also gives a large panel of recommendations that could have a positive impact on gender segregation.

Overall in UCC, only 25% of the SET academic staff is female. The proportion of women in full professorships in SET disciplines within the University is only 11% (i.e. 5 of 46 professorial positions). There is however a certain evolution in time: "*This compares with a study performed in 1993 in which 16% of the total UCC academic staff was female and only 4% of the full professorial complement*" (p.2). An analysis of HR appointments and promotion statistics reported that lower numbers of women than men applied either for promotion or appointment to senior positions. The proportion of women who applied and were successful was broadly similar to the proportion of men who were successful.

Three workshops have been carried out targeting different segments of the SET female research community. The first workshop concerning postgraduate women reveals some factors having implications specifically for women, that may affect their future career path in research. These factors are presented to be the following: "*In UCC, there is no support for pregnant PhD students or short term contract workers, and crèche facilities are limited. Guidelines on maternity support or maternity leave are not readily available or easily accessed; Research work requires commitment, is time-consuming, and the long hours working culture can cause difficulties for balancing a quality home life with work and study; There is a need to be constantly seeking funding, and that requires specialised skills. No training or guidance is provided in this area; Women feel they have to constantly prove themselves and that usually requires more work; Networks are dominated by men, and women find difficulty breaking into the circle*" (p. 9).

These are the recommendations addressed during the workshop: "[…] *It would be helpful for UCC to have a more professional approach, and to give encouragement and guidance. A better careers service that could provide work placements in industry was requested. A career path structure is needed, with post doctorates being given the opportunity to lecture. Consistency is needed in payment for demonstrations and tutorials – some people are paid, others aren't. Payments need to be reviewed for uniformity. It was suggested that training courses should be provided to cover areas such as health and safety, computing,*

and to provide clarity on funding applications. Better access is required to online journals. Access to general information is not readily available, especially maternity policies. More administration support and co-operation in departments would be helpful. Practical aids, such as access to hot water, storage for food and lunches, all within a kitchen and eating area would be appreciated and would improve the standard of existence" (p.9-10).

The second workshop was carried out with contract researchers. "*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 may have an effect. It was considered that the University frequently loses 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 PhD. It was thought that experience gained in achieving 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 career and family. Anxiety was expressed about taking maternity leave as this may block career progression. Women with a family found it difficult to socialize 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 at meetings. It was felt that the systems excluded women, they don't have the chance of getting to know people and this would be useful for writing proposals. These social barriers do not affect males in 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 "old boy" network. The group would not recommend a career in science as there is no defined career path, 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, UCC does not encourage teaching by PDs. Although academics are overburdened, departments will not pay or allow PDs to teach for academic experience. More formalized 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).*

In order to tackle these problems, "*UCC's family friendly policies should be implemented, even for contract staff, and these policies must be consistent across the board. The Human Resources website could be improved to give fuller and easier access to this information. The lack of females in senior positions means that there is a shortage of women available to take up gender issues. More administration support is needed, especially for returning women members of staff, for whom the transition would be much easier if teaching and administration support was continued for a few months. Opportunities should be given to 'bolster' CVs, e.g. lecturing experience, or personal development courses. Training should be provided for academia and industry, and could include the writing of grants or papers. It should be available to all staff, not just for new staff at induction. Guidance on alternative career strategies should be provided. Training in people management skills should be an essential prerequisite for supervisors and principal investigators. Other training could include: management of finance, proposal writing, preparing for industrial placements, how to be a successful team leader, and how to communicate effectively. A mentoring programme should be introduced to improve confidence, communication, and to help with career progression. An annual appraisal would be beneficial for highlighting anomalies, and to provide structured support and guidance. […] Contracts need to be reviewed to provide security, consistency and continuity. Flexi-time should be considered. Guidelines on rights and how to progress should be structured for Contract staff. A PDs representative is needed at Governing Body level to put views forward and to give feedback to PDs." (p. 11)*

Finally, the academic workshop included the following results: "*This group expressed concern about the misuse of women's good nature. Women are naturally more conscientious, and more giving, and this can be exploited. There is lack of recognition for work that is being done, e.g. female staff are asked to act on Selection Committees far more frequently than male counterparts, due to the need for gender representation on boards. As there is a very limited number of senior female staff in SET disciplines, this duty inevitably falls on a very limited number of people and draws significantly on their time. This attendance on Selection Committees is not recorded, or acknowledged as a load on an individual, or that it generates unequal workloads. For women returning from a career break there is a lack of recognition of achievements prior to the break. Although locums have been used to cover teaching, women return from maternity leave to mark exam scripts. They feel guilty if they don't. Teaching and administration support needs to cover the whole period as the female academic should not be expected to return from leave to mark exams or carry out essential administration. Women are dissuaded from part-time working because it is believed that the university culture does not encourage or support part-time workers. Another difficulty highlighted was, that to develop a research career the time commitment for women was in the late twenties when family issues are most prevalent. Women with partners and family at this time are discouraged from taking sabbaticals abroad as their partners may not wish to move with them, and it causes problems to move the children. They are also less motivated to focus on developing an academic career and leading a research team at this point in their lives. This can result in women opting out post-PhD from SET. In SET at UCC there are few senior women role models or possible mentors. It was considered that women lack confidence in their own ability, they feel isolated because there are no networks. Because of this they consider they may not be as goal-oriented as men, and believe men can be more focused. Men don't need as much support because they have the male networks. Women need to be given more support to progress in an academic SET career. […] Some women in the group have had experience of bullying and harassment. There is evidence of lack of respect for women, with the tenet being "you have to be more like a man"! The general consensus was that academia is not attractive to women with children, and the group would not encourage women into academia until things change. Because women are better at multi-tasking than men, this competency means more work, but onerous workloads are not being recognized. On the positive side, the group appreciated the security of tenure, and flexibility in time e.g. for attending to outside appointments." (p.12)*

The recommendations addressed during the workshop are: "*UCC should carry out a review of working hours, and actively encourage staff to complete their work within the 40 hours maximum. UCC should recognize the contribution of women on Selection Committees. Human Resources is neglecting to keep records of women on Selection Committees, the time commitment can be as many as 30 days per year. Approaches are made to female staff more frequently than male staff because of the need for gender representation on all committees. In SET disciplines the limited number of senior female staff necessitates that the duty falls on a limited number of people. The introduction of a scheme to improve the return from maternity leave was proposed. On return, the female scientist would have a period of 3-4 months free from teaching and administration responsibilities, and this would afford time to focus on research. Offer sabbaticals at UCC to enable women with families to focus on research and work to complete a specific task."* Other initiatives to be considered are: "*Male staff should be educated on women's contribution, and women should not feel they have to fit to a male environment. The lack of female roles models could be addressed by having more women at senior level in SET at UCC*".

Galligan, Y. 2005, *Assessment of the Participation of Women in Science, Engineering and Technology and UCC*, Ireland.

Interviews among female academics have also been carried out in Greece[1]. The results show that most researchers consider the lack of appropriate state policy and commitment towards children and family to be the main obstacles that affect their scientific career development. According to the interviews conducted, the lack of infrastructure and meritocracy were considered to create fundamental difficulties for

[1] Periktioni Female Researchers Network 2007, Chartografissi tou Epistimonikou Chorou tou Ellinikou Gynaikeiou Erevnitikou Dynamikou, [Χαρτογράφηση του Επιστημονικού Χώρου του Ελληνικού Γυναικείου Ερευνητικού Δυναμικού], National Documentation Center.

women to enter into the profession. Informal prejudices and lack of meritocracy were given as reasons for indirect discrimination. More than half of women recognized that female researchers face more problems due to family obligations and 76% suggested that their work interfered with their family lives, and 66% considered gender as an obstacle to career advancement. The study results led to the suggestion of policy proposals in general, referring mostly to the need of gender mainstreaming.

Kennedy (2005) also provides interesting information on women in engineering at the university. There are different sets of needs for female staff on temporary contracts and for those on permanent contracts. Women on temporary contracts considered mentorship and peer support very important for their career progression and were less likely to feel discriminated against on the basis of their gender. In contrast, those on permanent contracts did not place as strong a value on mentorship but preferred other mechanisms such as clearer promotional procedures. Those on permanent contracts also considered that family responsibilities had a negative impact on their output and deemed it important that regular reports be published on gender issues in their particular schools. Both groups advocate the availability of grants to support a career re-start up after a period of leave for maternity reasons.

Zvinkliene (2003) gives some insight in the position of women in science in eastern countries. He explains that in spite of society‘s democratization and recognition of equality between men and women, women’s subordination is deeply rooted in Christian culture that is heavily based on traditional role models. Women on the top of the social hierarchy, regardless of positive changes towards women’s representation at this level, were and are an exception rather than a rule. Moreover, usually these women represent power relations that pertain to a masculine world by definition. Despite the trend towards the so-called feminisation of certain disciplines, science is a highly masculine activity, with still visible divisions between masters and servants from a gender perspective.

The minor number of women in the highest academic positions is caused by the discriminatory practices hindering the advancement of women in science at all levels of their academic career rather than by the low level of professional ambition of academic women. Academic women could be considered as a discriminated professional minority although recognized as resolute.

Palomba, (2004) describes the career of women scientists as marked by “*factors such as age at promotion, disciplinary fields, and number of publications, are only a partial explanation of the gender differences in the career pathways in science. The main explanatory factor is and remains gender. Therefore, it would be absurd to accept that waiting for equality is sufficient when the evidence suggests that the wait would be a waste of time. Even to condone a short wait would be symptomatic of the patronising attitude towards the question of women’s participation in science*”. (p.124)

The fact that very few women are represented in high decision making bodies is an influetial factor that perpetuates women’s under representation. This is indirect gender discrimination because policy is male-oriented. Men tend to reproduce the traditional system in terms of research fields, hierarchies and individual performance (Lažnjak and Gaurina Međimurec, 1997). Many studies points out that the traditional male culture of academia tends to perpetuate over time (Husu, 2005; Novelskaite, 2006). Research in Lithuania (Novelskaite, 2008) effectively suggests that the small number of women in the highest academic positions is due to discriminatory practices rather than to the low level of professional ambition of academic women.

The traditional masculine culture of academia is then questioned in terms of neutrality and objectivity. Gender (in)equality in evaluation and promotion is intrinsically linked to vertical segregation. Indeed, it appears that the channels for women to broader scientific activity or academic recognition are weak. For example women are seldomly seen as referees when professorial posts are filled (Bruun et al., 1982).

According to Siemieńska (2007), young female scientists are less often perceived as “outsiders” by their male counterparts than in previous generations (full professors). However, men are getting more support than women in their scientific work. He suggests that the equalization of support for men and women in their scientific work will clearly contribute to increasing research productivity of women which already is similar to men’s.

Women are also placed in interdisciplinary fields (Beraud, 2003; Sagebiel and Dahmen, 2008; Koeller, 2001; With, 1997) and this could make it difficult to gain recognition in academia where mono-disciplinary settings is seen as “preferable”. Women scientists were less likely to apply for research funding and the funding was heavily biased in favour of traditionally male dominated disciplines (Menntamálaráðuneytið 2002).

Another factor that could be influencing vertical segregation is the fact that the demand of mobility of junior researchers coincides inappropriately with the period of life when most people establish a family and have children. The greatest pressure for achievement and embarking on a scientific career coincides with the establishment of a home and family: between the ages of twenty-five and thirty-five. The work implications of parenthood remain almost exclusively borne by women, fathers continue to invest little time in domestic and care tasks. One of the reasons for the inferior job and career opportunities of women is the rigid scientific career scheme at the universities. For example, in Austria, dissertation and habilitation form the prerequisites for a university career and; under the new University Act 2002; these prerequisites have to be fulfilled within 10 years. These circumstances may turn into barriers where private obligations must be combined with professional ones (Leitner and Wrobleski, 2009). The lack of widespread socio structural mechanisms to provide a better adequacy of family roles with academic career is also an important obstacle for women in academic careers (Forster, 2001; Kramer, 2000; Georgsdóttir, 2001; Ulmi and Maurer, 2005; Acar, 1994; Hegemann White, 1994).

C. Measures and policy actions

Strategies to set up equal opportunities policies have been implemented at several universities but the efficiency in terms of tangible results is sometimes questionable. In the UK, a study by Bagilhole (2002) has shown that despite the introduction of equal opportunities (EO) policies by many UK universities, academic staff continue to be male-dominated, particularly at the higher levels and in the more prestigious universities. The paper draws on data from a qualitative research study undertaken in a pre-1992 UK university. The main aim of the study was to measure the effectiveness of its EO policies for women. It uses Ball’s (1993) idea of problematising policies by looking at their ‘underlife’ in their ‘localised complexity’. The paper argues that distinctive aspects of academia produce and reproduce gender inequality. These aspects include: professional autonomy, an isolationist culture, and lack of good management. It is concluded that pre-1992 universities in the UK prove to be sites, which are particularly resistant to the change demanded by EO policies because of the special conditions of academia.

In Slovenia, during the transitional period, there has been a change in the status of scientists and researchers in society. The proportion of women in leading positions in scientific boards has increased. However, despite the favourable development in the proportional structure of the students and the "Young Researchers" project which gives more possibilities to women to reinforce the teaching staff and research groups, the faculty staff is traditionally male and changes very slowly and irregularly (Mladenič, 2007).

Norway can be put forth as an example of good practice. In Norway, equality work in universities has improved the situation, and more women have permanent scientific positions as well as leading positions today. In 1980, only 3% of professors were women while the proportion is 17% today (Hovdhaugen et al., 2004). However, the idea of a natural catching up of women with men in higher academic functions has to be rejected and the use of quotas has been proposed.

Törnqvist, M. (2006) examines the struggle over concepts and categories in Swedish gender politics. The provocative issue of quotas for women is used to explore these processes and the boundaries of the gender equality project. The study employs a discourse analysis of two intense media debates: gender quotas in the political sphere whereby every other seat in parliament is reserved for a woman (‘varannan damernas’) and a proposal to create 30 professorships and use positive action principles in the hiring process (‘Thamprofessurerna’). The design of the study is comparative, analysing two debates on seemingly similar policies that were put forward as a remedy for gender inequality and under-representation, but with very different outcomes. The central questions posed are: what are the conditions under which gender politics can be justified in different arenas of social life? When and why do certain

visions, problem definitions and solutions succeed or fail to get recognized? This study argues that the discursive terrain of competing ideas and visions partly embedded in the two fields, open or limit the possibilities for contested gender policies to gain acceptance. The analysis shows that whereas the policy of 'every other seat' is accepted and integrated into the political field in a way that creates new political possibilities for women, the attempts to increase the number of women with the help of positive action is met with resistance in the debate over the academy. Notions of democracy as representation pave the way for gender quotas in the political system, whereas ideas of meritocracy and individual creativity hinder the reception of positive action measures within the academy.

A solution to address the glass ceiling in academia has been proposed in Slovakia. The proposition is to "allow" lecturers a sabbatical once every 3 years. The workload would be reduced to writing monographs and doing research. This could help to change the glass ceiling perception of women (Kiczková, 2004).

Different recommendations are made concerning mentoring programs, career advice service, training and development programs, child care supports, family friendly policies, flexible working hours, monitoring workloads, networking, the need for gender balance indicators.

3.4.2.2. General – Public and private sectors

A. Description of the situation

The same remark as for the academic sectors can be made here: women that have the same or even better marks when graduating in science disciplines do not benefit from them when arriving in the labour market. This better performance is not reflected at the higher hierarchical levels in scientific and research occupations. The increase of women graduates is not consistently followed by an increase of women researchers in more prestigious positions within science and research institutions. Vertical gender segregation is then present not only in academia but in all scientific and research occupations in general.

Women are over-represented in lower level research jobs or among research assistants. In the hierarchy, their presence is often limited to the administrative or scientific advisory councils of research institutions. Moreover, researchers have proven that career development of professional women is much slower than that of men (Facchini, 1996; Dawid, 2002; Brandt et al., 2002; Fleckinger, 1999; Popovich [Попович], 2007. Women are less likely than men to reach higher positions and promotions in their professional career despite their qualifications.

<u>Public sector</u>

The position of scientific women in the Greek public sector has been investigated by Maratou Alipranti et al. (2001). The conclusions can be summarised as follows. Women scientists in research centres in the public sector constitute a minority; A large percentage of women employed in research are hired under project contracts. Female academics employed in research have fewer Ph.D. degrees compared to male researchers and women more often hold a postgraduate degree. Women's presence in high managerial positions and in administrative bodies of research centres is very limited. Gender still plays an important role in the allocation of positions of responsibility in research procedures; and finally, few women reach higher managerial positions. A similar report from 2006[1] does not mention any relevant changes in the situation.

[1] Maratou Alipranti, L. 2006, 'Gynaikes kai Epistimoniki Erevna: I Sychcroni Evropaiki Provlimatiki kai i Elliniki Pragmatikotita' [Γυναίκες και Επιστημονική Έρευνα: Η Σύγχρονη Ευρωπαϊκή Προβληματική και η Ελληνική Πραγματικότητα '] in S. Koniordos, L. Maratou Alipranti & R. Panagiotopoulos, eds. Social Developments in Modern Greece, Sakkoulas, Athens, pp. 207-224.

The second part of this research focuses on the researcher's participation in projects funded by the General Secretariat for Research and Technology[1]. The main conclusions are: scientific coordinators of the majority of the projects-coordination actions were men (average proportion ~90%), whereas women coordinators appear as a fairly low proportion, only 10% of women were appointed scientific coordinators of research projects on average; the examination of the distribution of project coordinators by sex shows a large variance, from 40%-50% in very few projects, while it drops to 2%-4% in others; female participation appears to be limited in actions aiming to develop industrial research, the improvement of business competitiveness and the connection of research with productive sectors i.e. activities that presuppose high specialization in the exact sciences or the sciences of engineering and technology; satisfactory female participation is noted in activities-projects related to the transfer or exchange of "know-how" - innovation or the information and introducing technological developments to citizens and students.

Ruiz Valero (2002) carried out a series of interviews at the Consejo Superior de Investigaciones Científicas (Spanish National Research Council, CSIC) among scientific female staff. The analysis of their opinions points out that women and men appear to have the same opportunities in the early stages of the academic career, but gender inequality grows as scientists progress in their careers.

A report by Crance (2002) on the representation of women in the CNRS (National Center for Scientific Research) in France underlines that the share of women researchers has barely changed in 15 years, although the evolution is contrasted according to the disciplines. At the highest positions, the masculine advantage is notable, although the share of women has improved. Finally, the author observes that even when there are a number of positions opened for promotion parity is not achieved. This report highlights some examples of disparities concerning the place of women in the CNRS, and concludes that during these past 15 years, men's privileged position has been reinforced.

Business and enterprises sector

In the UK, it has been observed that in the labour force, the increase in women's qualification level over the last 20 years has led to an increase in the number of women in managerial and professional roles but they are still underrepresented compared with men. Work culture and gender prejudice are the main causes (Crompton and Lyonette, 2007).

Wiemeler (1996) analyses the work field of female chemists at the BASF Company. Between 1918 and 1933, 27 female chemists holding a doctoral degree were employed as a result of a lack of possible male candidates due to war times. The analysis shows that employment of women was regarded as a transitional stage until they got married and were provided for by their husband, but it can be assumed that it also did not fit in with their own understanding of the role of women to work as married wives. 9 of the female chemists worked until their retirement at BASF but stayed unmarried. Two work fields could be detected in which women were employed: literature work without experimental activities as well as experimental laboratory work limited to tasks which were not related to production. The company linked workers' sex with specific work contents and career possibilities. The shaping of gender roles thus occurred at the company and societal level.

Wynarczyk (2007) investigates the "gender management gap" in the scientific labour market in the North East of England. The paper compares and contrasts employment, ownership, management structure and capacity between men and women in the Science, Engineering and Technology (SET) sector. The empirical investigation is based on a survey of 60 SET-based small and medium-sized enterprises (SMEs), operating in the North East of England. The results show that women are particularly under-represented in managerial and senior positions of scientific nature in the private sector in the North East of England. The "glass ceiling" effect appears to be widespread. There are very limited empirical data and research on the nature and level of participation of women in the scientific managerial labour market at the

[1] Maratou Alipranti, L., Teperoglou, A., Ketzetsopoulou, M., Tsigkanou, I. & Papliakou, V. 2002, 'Symmetochi ton Erevniton-trion sta Chrimatodotoumena apo tin GGET programmata (EPET II),' [*Βάση δεδομένων ΙΙ: Συμμετοχή των Ερευνητών-τριών στα Χρηματοδοτούμενα από τη ΓΓΕΤ Προγράμματα (ΕΠΕΤ ΙΙ)*.] National Center for Social Research and General Secretariat for Research and Technology, Athens.

firm level in the UK. There is a need for more rigorous research at firm and regional levels to examine the cumulative effects of underlying factors that prevent women from progression, beyond the "glass ceiling", in the scientific labour market. This paper builds upon a research project funded by the ESRC Science in Society Programme. The key findings have resulted in a subsequent award (a so-called Impact Grant) from the Economic and Social Research Council (ESRC) to establish the "North East Role Model Platform for Innovative Women" in the light of the Science City Initiative. The "gender management gap" in the scientific labour market in the North East of England has not, empirically, been investigated before and appears to be a highly neglected area of public policy and research.

Valgaeren (2005) searched for explanations for the meagre female representation at the top of the business world. Stereotypical conceptions about the characteristics of men and women are still no exception. They are part of many company cultures where they constitute a hidden but stubborn break in the progress of women to the top of the business world. The study is based on data collected from companies in the ICT sector. The organizational changes that lead to flexible career formation are intensified in the ICT sector. The method is based on a panel study in which respondents are followed for a longer period of time and also take part in in-depth interviews. The conclusion is that the nomadic career differs in many respects from the classic linear career but the analysis above produces a diffused picture of the gender aspects of the nomadic career. The image of the nomadic career certainly fits better with the reality of careers of women. Most men turned out successful in the classic linear career.

Singh and Vinnicombe (2000) analyse why women managers are often perceived to be 'less committed' to work than men, through an exploration of male and female managers' "meanings of 'commitment", to see whether they share similar meanings. Despite a large body of literature on the concept of commitment, managers' own meanings of commitment have not been reported. In general, engineers reported that they used the term 'committed' without defining what it meant. Their meanings were a broad composite of organizational and career commitment, focused on very strong affective commitment with almost no emphasis on continuance commitment, in contrast to the traditional (1979) definitions of commitment (Mowday et al. 1979). Results from this interview study of engineering managers and senior technologists (20 males, 17 females, 17 British, and 20 Swedish graduate engineers, from vice-president to senior technologist) show that there are differences in male and female engineers' unprompted meanings of commitment at work, as well as differences in meaning between the three levels of management sampled. Females responded more often with less visible 'commitment' meanings such as involvement, being people-concerned, and availability. More males (and top managers) used the term commitment to mean task delivery, being proactive, being innovative, adding value, and being ready for challenge. The gender differences identified in reported meanings could impact on the assessment of women's commitment, when evaluated for promotion, career development and professional chartered status by mostly male engineering managers. Why is it important? High Technology Engineering includes high levels of research and development. The conclusions drawn from this paper are applicable to Engineering research.

Boes and Trinks (2005) explain that due to increasing market pressures in the IT industry and to the worsening of the conditions for highly skilled women, their careers are increasingly threatened because of unfavourable working hours and a lack of compatibility between professional and family life.

B. Causes and explanatory factors

Vertical segregation in science and research has the same roots as vertical segregation in general. The causes and explanatory factors are varied. Several are presented here from social stratification in general to very specific mechanisms operating in scientific institutions.

A recent comparative study from Bosch (2002) of women in science has revealed that the situation in the Netherlands is worse than in other European countries. This raises the question whether there is a "Dutch case" concerning women's standing in science. The author argues that the cause is not to be found in a special brand of Dutch Protestantism, with its strong emphasis on motherhood and the family, and impact on labour patterns and social organization. The real cause is rather stratification along religious and political lines. There is a specifically Dutch segmentation of society along religious and political lines, called verzuiling, literally "pillarization." From about 1880 until far into the 1950s the personal and social

life of the Dutch (from schools to sports and ladies' organizations) was organized into four recognized pillars (a Protestant, Catholic, socialist and a liberal pillar), which at the top were represented in political parties. This article analyses the often overlooked fact that between 1880 and 1945 state institutions, such as universities, were thoroughly pillarized, which strongly influenced recruitment and selection in those institutions. Historically, the process of 'democratic pacification' (via pillarisation in the Netherlands has led, on the one hand, to tolerance and accommodation, mainly in the public sphere, and to basic income policies, and on the other, to a strengthened idea of family privacy and women homemakers. According to Knijn (1991), the Netherlands, has a low level of individualisation, no equal access to either the labour market, the polity, or state institutions, and a very low state and market household service profile. This helps to explain why no woman was appointed to the rank of full professor at any state university until after 1945. The Dutch case might also be explained by the many reorganizations and down-sizing of universities of more recent years that occurred simultaneously with the expansion of academic feminism. In addition, a newly configured "pillarization" has driven deep divides between gender studies scholars, equal opportunities officers, and women scientists.

Reis et al. (2001) explained why Portugal has a strong presence of women in the scientific community. "*Two historical reasons related to social and political aspects of the Portuguese society may account for the great number of women scientists in Portugal. […] the percentage of women in the traditionally "feminine" degrees, such as literature and languages was very high, but the percentage of women studying exact and natural sciences (in particular mathematics and biology) was also much higher than in most developed countries. The explanation for this lay in the social selectivity of the Portuguese higher education system, which favoured the access of the more privileged youth to University, independently of the sex. […] Women's access to the higher education system was therefore facilitated by their social status. During that period, selection based on gender was particularly noticeable in the professional world, where women represented the majority of the teaching occupation at all levels except university*". (p.1) The authors continues by saying that "*Neither social class nor the individual achievements fully explain the situation of women in science, according to these authors. This survey showed the existence of "invisible" barriers to women's access to science and technology fields, to the top of the professional career and to positions, which are related with power and scientific influence. Although the barriers to women's advancement in the career appear overall in the scientific community, they are particularly accentuated in the exact and natural sciences. The longest history of these scientific fields in Portugal and the greater competition may explain the gender differences. However the most recent data shows a significant progress in the situation mentioned before".* (p.2).

As well as for the academic sector, the process of infiltration of women into decision-making advances very slowly. There are almost only men among the members of executive bodies of science policy. In Slovenia, women are said to rarely aim for leading positions (Andolšek Jeras, 1997). This is quite a common debate, other studies have ascertained whether women are less oriented to compete for leading positions or not or whether they are excluded because of mechanisms of gender discrimination.

In the process of appointment to a certain position not only professional achievements are at play, but also informal recommendations and support of colleagues (preferably male) which is sometimes lacking for women (Ziliukaite, 2006). According to Fletcher et al. (2007), the lack of transparency, increased competition and lower levels of collegiate activity coupled with networking based on homosociability are contributing to a research production process where women are marginalized.

Different perceptions of 'commitment' between men and women impact on how women and men are evaluated for promotion; efficient management is identified with masculinity, which favours the promotion of men (Singh, 2000). On the other hand it has been shown in the UK that women tend to deal with barriers in a way which perpetuates existing work cultures (Dainty et al. 2000). The power of the glass ceiling effect can vary according to fields of science. In Belgium for example, the glass ceiling appears to be stronger in the ICT sector (Valgaeren, 2005).

Concerning the combination of career and private life, there seems to be a negative relation between career evolution and parental leave in Sweden (Hansson and Möller, 2009). The design of fellowships for single child-free individuals makes it difficult for women to return to science after a career break (Taljunaite

and Zvinkliene, 2001). However, research in Germany shows that successful doctors in medicine combine professional with private life in an optimal way (Hohner et al., 2003).

Haffner et al. (2006) show that female careers develop more slowly and stagnate earlier compared with men's careers. Women who are self-employed are, in contrast, comparatively more successful, although women and men are equally well educated. The analysis of the sample revealed that the business sector is most important for the employment of university graduates, but in this sector female chemists and engineers are especially under-represented. Differences in private life may help to explain this: women's private relationships are characterized by a dual career couple situation. Results show that mothers (38.4 percent) are on average more successful in their job than childless women (27.3 percent). This is true although working mothers are also mainly responsible for child care – only four percent of them live together with a jobless partner. The authors conclude that the most decisive factors that hinder the employment of high skilled women is the prevailing working culture with its claim of all-time-availability. This factor is more decisive than being a mother. This working culture hinders non-professional commitments and supports the conventional model of family and parenthood of a male breadwinner with financially depending wife and some kind of 'virtual' fatherhood.

Interesting research has been carried out on women reentering the scientific career:

Box 14: Widening of Employment Opportunities in ITEC – Professional Advancement through ITEC Skills

The purpose of the project was to identify employment areas outside the traditional IT sector where demand for IT skills is increasing, and to highlight the possibilities for new types of careers for women, including those returning to the labour market following a career break. The project examined case studies of newly-emerging occupations with the aim of investigating whether there is in these occupations a positive employment culture with career development opportunities for women. It is hoped that the results of this work will be used to encourage women to consider careers in different scientific and technical professions from those which they might normally be aware of. This report presents the results of fifteen case studies of new occupations and of women working within them. It showcases path-breaking women professionals working in some of the newest areas of information technology, science and engineering. The examples show that: new ITEC occupations are considerably more diverse than the conventional image of ITEC work tends to suggest, there are many different entry points for new ITEC professions, and it is important that women considering entering them are aware that not all of these are through conventional, formal educational channels. More clarity is needed about progression pathways and career development routes for ITEC professionals once in employment. The most 'women-friendly' ITEC employing organisations are those which have clear, coherent and thoroughgoing equality or diversity frameworks. The women's work is described, the skills requirements of their jobs are analysed, and the report also considers the organisation of training, learning and career progression opportunities in these new professional areas. At the end of the report, some conclusions and recommendations are made for changes in both organisational and public policy, designed to help draw women into new ITEC professions.

Equalitec, DTI & Webster, J. 2006, *Widening of Employment Opportunities in ITEC – Professional Advancement through ITEC Skills*.

C. Measures and possible changes

Little research has been done on the measures and policies regarding vertical segregation outside academia. However, one can state that even in countries where legislation and measures have been introduced, the glass ceiling effect persists. According to Þórisdóttir, (2002), the underlying reasons are due to a mixture of culture and traditions, subjective and objective barriers, and gendered discourses. The male career model shows resistance to change (Matthies, 2005).

Research in the UK mentioned that legislation, anticipated skill shortages and changing employment patterns have little impact on employers' preferred skills formation strategies (Sappleton and Takruri-Rizk, 2007). Even comprehensive supportive measures for increasing equality between women and men could not avoid that the female share at the higher levels of the hierarchy in science remains low (Leitner and Wrobleski, Country report Austria, 2009).

The results from Wroblewski et al. (2007) clearly indicate that selective single measures achieve their principle targets to a lesser extent than measures which combine different approaches. But using synergies from different interventional procedures requires a coordinated set of measures with a clear definition of goals. During recent years the measures set up to promote women in science and research in Austria have a strong focus on detecting and using synergies, which is demonstrated best by the FORTE-initiative (for women in research and technology) that combines different types of measures as well as target-groups and contents.

Simon (2003) recommends the development of a new organisational culture in which promoting models of gender equality will be made possible.

It has been suggested that flexibility in terms of the amount of years in recruitment positions and a good mentor relationship are important strategies which can facilitate career advancement for women scientists, and that improved working conditions for women can compensate for the lack of balance in terms of the division of childcare responsibilities between women and men (Corneliussen, 2009).

4. Statistical Gaps and recommendations

Although the topics of horizontal and vertical segregation in Europe are extremely well represented in the Gender and Science data base, research remains relatively limited. Limitations take different forms. First, existing studies rarely compare different countries but mostly focus on the situation in one specific country. Second, studies are often limited to the academic sector, few analyse the other institutional sectors. Third, most studies apply basic methodology and the approach is essentially descriptive. Indicators are only rarely computed and multivariate analyses are almost completely missing. Fourth, only rarely do studies adopt a life cycle perspective using longitudinal data, the great majority illustrate the problem of segregation at one moment in time at one stage of the life course. However, a life course approach would potentially be very useful to improve understanding of phenomena such as the leaky pipeline or the glass elevator. Fifth, most of the existing research is quantitative. There is thus a need for more qualitative research based on interviews or the conception of large-scale surveys that could offer a different view on the precise processes underlying segregation in science and research. Such research could also increase understanding of men's under-representation in certain fields of science such as the humanities and of the phenomenon of the "glass elevator", e.g. in health services. Sixth, there is a lack of in-depth analysis of the roots of segregation. The literature offers mainly case studies that show that the choice of study field, stereotypes and the unequal care burden that prevents women from concentrating solely on their career, the search for shorter working hours and the covert biases or forms of impediments in organisational practices constitute important factors that are linked to segregation (Bettio and Verashchagina, 2009, p. 9). Finally, few analyses assess the efficiency of existing policies, let alone propose innovative policies. The usefulness of quota's with respect to women's presence at each of the echelons of a scientific career be it in the academic or private sector, on scientific boards, research councils, etc is not studied. The literature offers no debate on quota policies.

4.1. Statistical gaps

The gaps in the existing literature are at least partly due to the fact that data that allows one to analyse segregation are scarce. Existing data concerning science, engineering and technology mask women and their difficulties, questions and responsibilities. The harmonised sources of information in Europe (European R&D Survey, European Labour Force Survey, Unesco/OECD/Eurostat Education database, European Structure of Earnings Survey) are still inadequate for the purpose of analysing women in research.

R&D surveys are the most appropriate instrument for collecting data on R&D activities, expenditures, funds and personnel. However, R&D surveys do not provide insight into the living and working conditions of researchers. As a result, labour force surveys might be a useful complementary data source.

Throughout Europe, the R&D survey is conducted in coordination with Eurostat and according to the standards and guidelines of the Frascati Manual, adopted by the Organisation for Economic Co-operation and Development (OECD) as the terminological and methodological basis for the collection of statistical data on research and development. Therefore, the category of female researchers can easily be identified through the European R&D survey:

Researchers are defined as scientists or engineers engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned (Frascati Manual 1993, pp 279 ff)

The thematic coverage of the European R&D Survey comprises a number of personal and employment-related variables of R&D personnel: sex, occupation, level of qualification, field of science, industry group and type of enterprise. For data concerning R&D expenditure and personnel, a distinction is made between four institutional sectors: business enterprise, government, higher education, and private non-

profit. R&D expenditure is further broken down by source of funds, by fields of science, by type of costs, by type of activity, by size class, by type of R&D, by fields of science, by socio-economic objectives and by regions. Data on R&D personnel is further broken down by occupation, by qualification, by gender, by size class by citizenship, by age, by fields of science and by regions. However, the survey design has not been fully harmonised yet which sometimes seriously constrains any analysis of female scientists.
An important advantage of the R&D Survey is that data are presented for full-time equivalent (FTE) and headcount (HC) units but unfortunately not all national R&D surveys collect/publish both these units of measurement. The HC unit expresses the total number of persons involved in R&D activities, while the FTE unit expresses the number of person-years and is used for identifying the whole time spent on R&D activities. FTE is thus the most appropriate unit for measuring research employment, while HC is basic for analysing the volume and characteristics of R&D personnel.

A drawback of the Survey is that it insufficiently and varyingly covers enterprises that carry out R&D activities (cross-country variation in survey and sampling design). In general, there is a lack of coverage of non-manufacturing and smaller firms so that the total of R&D personnel is underestimated.

To sum up, while the main advantage of the R&D Survey is that it allows for a clear identification of the category of female researchers, information on qualitative aspects of their employment (part-time/full-time, temporary contracts, job tenure, home working, size of enterprise, combination career and children, etc.) is very limited.

As a result, on the demand of the European Commission, the Helsinki Group collaborated with the Women and Science Unit of the DG Research to produce a data base of primary data on research and to develop a set of gender-sensitive indicators. This database has become known as the Women in Science (WiS) data base. Since its creation, most efforts have been made to enrich and harmonise the data provided by the European R&D Survey. However, WiS in itself has not yet succeeded in establishing a complete and harmonised data set covering all European countries.

The second major data set at the European level is the ELFS. Since the LFS is mandatory for all European countries, a significant degree of harmonisation is achieved with respect to the definitions used, the survey design, and the survey's timetable. All data are broken down by sex and employment data are collected in HC and FTE. Moreover, this data set provides very rich information on the quality of work of respondents but none on wages. ELFS occupation and education definitions are linked to the United Nations classifications: the 2-digit disaggregation of the International Standard Classification of Occupations (ISCO) (ILO, 1968 and 1990) and the International Standard Classification of Education (ISCED) (UNESCO, 1976 and 1997). At the sectoral level, the Statistical Classification of Economic Activities in the European Community (NACE) (Eurostat 1990) is used. In most countries, however, data are only partially broken down by public and private sector. Moreover, the ELFS does not allow to clearly distinguish 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). The term HRST refers to human resources actually or potentially devoted to the systematic generation, advancement, diffusion and application of scientific and technological knowledge. In the widest possible sense, the term includes all persons who have successfully completed tertiary education (ISCED97 levels 5 and 6) or work in a scientific and technological occupation (ISCO88 major groups 2 (professionals) and 3 (technicians)). The Canberra manual provides further details on the concept of HRST. Given that the occupational and sectoral definitions and classifications used in this survey are general and were not specifically designed for the analysis of R&D personnel, some assumptions need to be made. For example, it is assumed that all researchers belong to the major group of "professionals" (ISCO88 major group 2). Moreover, the group of university-level HRST includes all people who have successfully completed university education or who work in a scientific and technological occupation. However, researchers are a much narrower group than university-level HRST, they exclude suitably qualified people working in non R&D activities or not working at all.

To sum up, while the main value of the ELFS lies in its richness of information with respect to the quality of employment of female researchers, it is very hard to clearly isolate the exact target group in the ELFS data base.

Wage information is completely absent from both the European R&D Survey and the ELFS. The European Structure of Earnings Survey is the European database most suitable for an in-depth analysis of wages by personal and labour variables. However, the ESES does not provide sufficiently disaggregated information at European level on occupation and education to identify scientists and engineers, not to mention researchers.

Inflow data from education into HRST (human resources in science and technology) are available from Eurostat's Education database and are collected via the UNESCO/OECD/Eurostat (UOE) joint questionnaire on education. National Statistical Institutes or Ministries for Education compile the national data, in many cases extracted from administrative registers. In addition, Eurostat collects data on regional enrolments and foreign language learning. Even though the official definition of HRST in the Canberra Manual contains the letters 'S&T', the definition is not restricted to science and technology. HRSTE covers all fields of study i.e. anybody who successfully completed a tertiary level education.
The database provides useful measures of the current and future supply of HRST. Inflows can be sub-divided into various groups, each providing a different focus. The data on actual inflows ('graduation'; i.e. students completing a university level study) and potential inflows ('participation'; i.e. students enrolled in higher education) from the education system into the HRST stocks are annual.

Some specific remarks for countries could be added here. The Hungarian report for example mentions the unavailability of data on: staff by category and age; staff by hierarchical position; staff by highest academic qualification; members of decision-making boards/panels; payments in different positions; citation index and number of publications; number of international projects; number of national projects; recruitment procedures (data on applications/admissions; promotion procedures - who decides, applications and actual promotions). The lack of a comprehensive report on the status of women scientists in the Italian university system has been reported. In Lithuania, gender segregated data are not always systematically available. In Poland, existing studies do not take into account statistics concerning sex/gender in the growing private sector of education, except in tems of general data of women's share of students within the non-state institutions of higher education. They don't reflect on the domination by men in the non-governmental industrial sector connected with science. This gap in the data means they are only able to recognize the main trends of the social-political transformation in Poland regarding sex/gender relationship i.e. segregation horizontal and vertical in a very limited way. In Romania, very few studies and research has been undertaken aiming at mapping the gender horizontal and vertical segregation. In Slovakia, it is still challenging to find the necessary data organized by gender, over longer periods of time, and in specialized statistics publications. In Slovenia, there is no separate statistical data for faculties except the Faculty of Arts (in general and some departments) and the Faculty of Pharmacy of the University of Ljubljana. Finally, in Sweden although a long tradition in research of horizontal and vertical gender segregation exists some sectors, like technology, medicine and education, are more researched than others.

Given the flaws in the European-level harmonised datasets, we believe that when it comes to studying women in science, the best available data are those of She Figures. In 2001, 2006 and 2009 the Statistical Correspondents, a subgroup of the Helsinki Group for Women and Science, collected sex disaggregated R&D statistics that have been published in three editions of the booklet She Figures. Besides data on human resources in science and technology and researchers by economic sector and field of science, now collected by Eurostat, these publications include data on seniority of academic staff, participation on scientific boards and research funding.

4.2. Recommendations

European comparisons

Studies rarely compare different countries but mostly focus on the situation in one specific country. 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 available research.

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 because of varying coverage: different time frame, different disciplines, samples, etc. More unified, homogeneous and systematic research for all European countries is needed to overcome this persisting fragmentation of research.

As a result, European initiatives should be applauded as they allow for cross-country comparisons. For example, the publication She Figures (2003, 2006, 2009) (EC, 2004, 2006, 2009b) has greatly enlarged the understanding of the problem of segregation and its possible remedies.
Also, the adoption of two European indicators on horizontal and vertical segregation that are annually followed up and monitored should be set forth as a good practice (cfr. European Commission (2009),« Indicators for monitoring the employment guidelines - 2009 compendium », DG Employment, Social Affairs and Equal Opportunities).

European-level efforts should still attempt to improve private sector research coverage. Indeed, the academic sector is studied much more extensively than the private sector.

Methodology and indicators

In methodological terms, most studies apply basic methodology: state-of-the-art reports or compilation of statistics. Quantitative empirical research is too often descriptive. Indicators are only rarely computed and multivariate analyses are almost completely missing. Moreover, rarely do studies adopt a life course perspective, the great majority illustrate the problem of segregation at one moment in time, one stage of the life course. However, a life course approach would potentially be very useful to improve understanding of phenomena such as the leaky pipeline. Most existing research is quantitative. There is thus a need for more qualitative research based on interviews or the conception of large-scale surveys that could offer a different view on the precise processes underlying segregation in science and research.

Explanatory factors

In-depth studies on the roots of segregation are lacking. Case studies show that the choice of study field, stereotypes, the unequal care burden and consequent inability to prioritize income commitment, the search for shorter working hours and the covert biases or forms of impediments in organisational practices constitute important factors that are linked with segregation (Bettio and Verashchagina, 2009, p. 9). The influence of these factors varies across countries and national contexts but also across sectors. In general, a positive correlation has been observed between the level of women's employment rate and the level of segregation.

The problem of 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: why are there so few boys in disciplines such as history, philosophy, and so forth? The reasons why study field choices are gendered include stereotypes often found in children's books and school manuals; gendered attitudes of teachers, gendered advice and guidance on courses to be followed; different parental expectations regarding the future of girls and boys; and so forth. As a result, some professions are seen as for women and others for men. The absence of a mixed gender composition in the different fields of study can already be observed in secondary education, which is in

turn reflected in higher education. If the aim is to change these trends and introduce more of a gender balance in all study fields then all factors beyond secondary education and study field choices need genuine theoretical and political questioning., 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.

Social norms and parental expectations are important determinants of segregation that are nevertheless only scarcely covered in the literature. There is thus a need for more qualitative analyses on these factors. Precise questionnaires could interrogate scientists and researchers on how they have experienced pressure emanating either from society in general or from within their closer family environment.

Many studies point to women's role as mothers to explain why they climb up the hierarchical ladder more slowly in the field of sciences, -be it in the academic or private sector. The unequal distribution of the care burden and of other domestic responsibilities is taken for granted and adopted as an evident assumption that underpins studies on segregation in science and research.
Finally, it is striking that discrimination is rarely analysed as an explanatory factor of gender segregation among scientists and researchers. The subtle impact of discrimination is only rarely questioned. On the contrary, most studies are highly gender biased in the sense that they present gender segregation as resulting from the fact that women fail to make the right "choices".

Policies and measures

Very few studies examine the role of policies, evaluate policies, formulate policy recommendations or propose innovative policies. For example, the usefulness of fixing quotas in order to reach a critical minimal proportion of women in decision-making is not analysed in the studies in the Gender and Science database. The data in She Figures 2009, (EC, 2009b) show that in terms of women's presence on boards, the Nordic countries stand out from the others: in Sweden, Norway and Finland, the share of female board members exceeds 44%. This is at least partly due to the fact that an obligation exists in some of these countries to have at least 40% of members of each sex in all national research committees and equivalent bodies. As of today, there is just little information about the participation of women in program management and implementation and about their representation on scientific boards and other decision-making research bodies. In many countries, there is neither concern for, nor a clearly stated policy to address this situation.

Moreover, there are almost no evaluation studies of the effectiveness of so-called inclusion measures for girls/women in science, engineering and technology. At the same time, there is also a lack of cohort analysis that would allow one to follow the professional paths of young women who were previously affected by such policy measures. There is also a need for more in-depth studies on the existence and effectiveness of measures to work against the feminisation of some study and job fields. It would also be useful to assess the effects recent reforms in hiring practices on men and women's career paths.

Webster (2007) draws several recommendations to tackle gender segregation in the labour market in general. These should be applied to the field of science. She argues that even if gender segregation may be slowly eroding, women remain unable to fully develop and secure high quality work on equal terms with men. The reasons for women's labour market segregation were found to be "*complex and interlocking, and the policy response to the problem needs to be equally multi-faceted. The policy implications of this work are that labour market segregation needs to be addressed at several levels and by several policy actors:*

- *Company recruitment, training and employee development practices to be oriented to clear progression systems for women.*
- *In organisations, restructuring should be designed so as to create rather than destroy progression opportunities.*
- *Trade unions should intervene in the design of women's jobs to ensure that work processes and skills labels properly valorise and legitimate the skills which women use, even when ghettoised in 'low-skill' jobs.*
- *Trade union officials need to be trained in equal opportunities issues.*

- *Public authorities should strongly support training initiatives which focus on the needs of women in low-grade positions, in wide-ranging skills.*
- *Public authorities have an important role to play in promoting the take-up of equal opportunities policies by public sector and service organisations.*
- *[…] assumptions about the suitability of men and women for different careers need to be challenged among young people, trainers and employers. Information provided to students should cover the gendered features of the labour market (low status, low pay); the advantages and disadvantages of non-traditional jobs; and potential earnings and effects on standards of living of particular career choices" (p.26).*

In addition to these general recommendations, one can mention the need for role models in order to change the image of science, the need for a curriculum reform in order to attract more girls or women into the scientific disciplines. Concerning vertical segregation, changes in the organisational culture that is qualified as traditionally masculine are necessary to positively influence evaluation and promotion criteria.

5. Conclusion

Labour markets in all European countries are characterized by horizontal and vertical segregation. The evolution over the last 20 years points towards stagnating if not rising levels of segregation. This shows that the rise in women's employment concerns only specific sectors of economic activity and education. There is no evidence of a spontaneous movement towards less segregation on all European labour markets.

Concerning science and research, a revolution has occurred over the last 30 years. The increase in women's level of education has been so as to catch up and rise beyond men's. In higher education, women constitute the majority of bachelor and master students and they even represent 45% of Ph.D. graduates. If the growth rate in the number of male and female Ph.D. graduates as it was observed in 2000 is sustained, women will soon catch up with men at this highest level of education as well.

However, differences in educational fields still exist even if the percentage of women has risen in all fields. At the Ph.D. level, most fields are dominated by women: education, humanities and arts, agricultural and veterinary sciences, health and welfare. Female PhDs represent 47% in social sciences and law and 41% in mathematical sciences and computing but only 20% in engineering, manufacturing and construction.

The remarkable rise in women's level of education is related to the growth of women's employment in the field of science and research. The share of women in total research employment has been growing at a faster rate than men's in most European countries. However, there are large cross-country differences.Horizontal and vertical segregation are also a common feature in the field of science and research.

Women represent on average throughout the EU 37% of the total employed research population in higher education, 39% in the government sector and only 19% in the business and enterprise sector. Based on the compound annual growth rate across sectors, a difference can be observed between the higher education sector and the private and business sector. In the former the compound annual growth rate in the number of female researchers has been stronger than that of men over the period 2002-2006 in most countries. There seems to be some move towards a more gender-balanced research population in higher education. The government sector presents very similar pattern. However, for the business enterprise sector, the compound annual growth rate of the number of female researchers has been stronger than that of men over the period 2002-2006 in only the half of the countries. This shows that women are catching up with men at a slower pace in the business and enterprise sector compared with higher education and the government sectors.

There are also differences in the evolution of the research population according to the field of science. On average throughout the EU-27, the most positive growth figures have characterised the fields of medical sciences, humanities, engineering and technology, and the social sciences. Only in the natural sciences has the number of female researchers actually shrunk at a yearly rate of -0.4% over recent years. The situation varies widely according to the different European countries. It was observed that: "*Given the severe under-representation of female researchers in engineering and technology, what is most encouraging are the extremely high positive growth rates that are observed in this field for some of the countries." (She Figures 2009 p. 43, [EC2009b]).*

Concerning vertical segregation, its evolution is harder to investigate since data is only available for the higher education sector. Some more general tendencies can however be highlighted. The comparison between the years 2002 and 2006 shows an improvement in women's relative position, at the PhD level but also at the different stages of the academic career in grades A, B and C. This improvement appears to be very slow. It is then obvious that without proactive policies, it will take decades to close the gender gap and reach a higher degree of gender equality. A positive factor that is worth mentioning is that there is a more marked closing of the gender gap among scientists than in the labour market in general. The

dissimilarity index has also decreased between 2004 and 2007 (or in some countries it remained stable). These findings lead us to believe that the career situation is more favourable for the youngest generations of female academics. However, the gender gap is still disproportionately high compared with the increase in the proportion of women amongst students. The hypothesis that women will automatically catch up must be rejected.

It is also worth noting that the proportion of female grade A staff between 2004 and 2007 EU-25 increased from 5.8% to 7.2% in the field of engineering and technology; from 15.6% to 17% for medical sciences (the lowest evolution) and from 23.9% to 27% in humanities.

However, the most important institutions and areas of decision making in the scientific landscape remain dominantly led and managed by men. In policy terms, introducing gender quotas, as it is the case in some Scandinavian countries, could have positive consequences for the evolution of vertical segregation and could lead to a better representation of women in science.

Even if the HRST population is characterized by strong vertical and horizontal segregation, a comparison of segregation levels in this population with those that prevail in the labour market as a whole shows how the former have an advantage. Indeed, segregation, although strong, is lower in this more specific group of highly qualified workers than in the total workforce.

In the Gender and Science database a large number of publications deal with the topic of segregation in science. However, compared with the studies on segregation in the entire labour market, the publications focusing on scientists and researchers appear to be mainly descriptive without in-depth analysis of the roots of segregation and of the policies that could be implemented to tackle segregation. It is worth underlining that a great part of the literature in the database appears to be gender biased as it presents as the major cause of segregation the “choices” made by girls and women, thus ignoring boys’/men’s choices, thereby taking the male pattern as the model. Other explanatory factors discussed in the general literature on segregation are less investigated when segregation is studied in the population of researchers and scientists. For example, discrimination appears to be neglected as an important explanatory factor.

Comparative studies are very limited and longitudinal analyses are rare. This could be in part associated with the lack of data concerning the workforce employed in science and research activities. This lack of data also explains the focus on the academic and higher education sector where data are generally available even if it poses difficulties in comparing across countries. European initiatives like the publication of She Figures on a tri-annual basis since 2003 has to 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.

6. References

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