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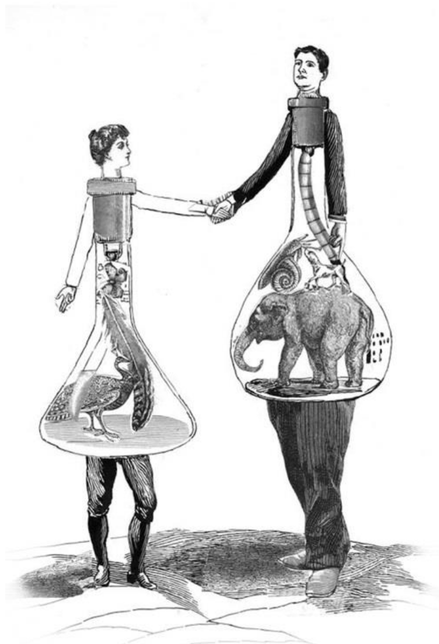
MASTER'S THESIS

GENDER DIFFERENCES AND THE ROLE OF SOCIAL CAPITAL IN ACADEMIC PRODUCTIVITY



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Abstract

In this thesis we investigate gender differences and the role of social capital in academic productivity. We use a manually collected dataset of 131 academics within the field of biology in the UK. We use statistical tests to find out whether there are gender differences in productivity and how social capital relates to productivity. When testing three different groups of academics - who received their PhDs in the 1970s, the 1980s or the 1990s - our results show mixed findings in terms of gender differences within academic productivity. By using previous literature, we are able to come up with reasons for why we see the gender differences that we do. Furthermore, our results show a positive and significant relationship between quantitative productivity and social capital. By drawing on literature we are able to decipher the implications from this relation.

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1. Introduction

The United Kingdom (UK) has been suggested to lag behind other countries in terms of female representation in academia. The first female to receive a PhD in Chemistry in America did so in 1873 from MIT. Meanwhile, it was not until 1948 that Cambridge University began awarding degrees to women, as the first in the UK ("The Guardian", 2012). Looking at more recent events, the UK still seems to lag behind in terms of female representation in scientific and engineering careers. Among 44 fellows appointed by the UK's Royal Society in 2012, only two were women. At the same time, 84 scientists were elected to the US National Academy of Science, of which 24 were women ("The Guardian", 2012).

Women are still underrepresented in science in the UK, accounting for only one fifth of the UK professors in 2012. This has amongst other resulted in heavy debates about inequality and prompted initiatives that aim at increasing equality for women and men in science. Gender differences are especially observed within science, technology, engineering, and mathematics (STEM) where women account for only 17% of the professors in the UK ("House of Commons", 2013/14).
The low representation of women in science translates into an issue of gender equality and violates the rule of universalism, i.e. that all people with talent should have access to a scientific career regardless of gender, race, and other social attributes (Etzkowitz et al., 2003, chapter 2). Further, the low representation of women in science creates an issue with untapped potentials and human capital, which science forego by not having more women in the workforce. It has been estimated by the UK Society of Biology that increasing women's participation in science is likely to be worth upwards of £20 billion ("House of commons", 2012/2013, p. 7).

The issue of gender differences in science not only results in lower representation of women, but also has an influence on women's levels of publication productivity, which by many has been shown to be lower than that of men. In academia, publication productivity is integral to the status, success, funding allocations, and advancement of researchers (Etzkowitz et al., 2003, chapter 2, Bird, 2011, Creamer, 1998, Leahey, 2006, Fox, 2005). Thus, the amount of research and studies finding lower levels of publication productivity for academic women compared to men is concerning. Research has come up with several explanations as to why female academics are less productive than their male counterparts. The suggested explanations cover a wide array of topics, such as family –and marital status, work activity preferences, institutional barriers and so forth. However, a more recent concept has prompted researchers to speculate in its explanatory powers in relation to academic publication productivity. This concept is social capital. More specifically, social capital is about the informal relational aspects of networks, and how these facilitate information, validation and encouragement (which also facilitate getting work done, i.e. productivity). Social capital therefore relates to the access to productive resources through social relationships.

The conduct of science has through the last several decades transitioned from being an activity mainly for the lonely scientist, into something that is conducted in larger groups of people. This also means that more people publish the findings and publications together. The increased reliance on co-authors and collaborations within science highlights a potential importance of social capital in relation to academic productivity. However, literature suggests that men have more social capital than women, which might facilitate their higher levels of productivity. The concept of social capital has therefore been suggested by literature to potentially explain some of the gender differences in productivity. Most literature has measured social capital through surveys and interviews, and not yet applied it to specific fields of harder sciences. To our knowledge, existing literature has not looked into the issue of publication productivity and gender differences in relation to social capital, measured by the number of co-authors, in the field of biology. The aim of this thesis is to fill this gap by examining the reasons behind gender differences in productivity and social capital's relation to this for academics within the field of biology in the UK.

We want to understand the potential reasons why women seem to have a lower productivity than men. Additionally, we want to investigate whether social capital relates to productivity. In order to do so we have developed the following research questions:

1. *What are the reasons behind gender differences in academic productivity?*
2. *What is the role of social capital in relation to academic productivity?*

In order to answer the research questions, this thesis will start by giving a thorough review of previous literature. Firstly, we look into productivity and some of the suggested reasons why gender differences exist within academic productivity. Next, we look at social capital and its potential influence on productivity of women and men. We then combine the two bodies of literature with the aim of providing a complete theoretical framework for this thesis.

This thesis proceeds as follows. First, chapter 2 provides an understanding of the context in which we base our analyses. Thus, we go through the UK setting for academics. The next chapter will provide a theoretical foundation on productivity, gender differences therein, as well as social capital. Chapter 4 will present and evaluate our data and methodology. Next, chapter 5 will provide an in-depth analysis and presentation of our findings. Further, we will combine our findings with those of other literature. Chapter 6 presents a discussion, and brings forth implications of our findings. Chapter 7 highlights limitations of this thesis, while chapter 8 presents the final conclusions.

2. The Academic Setting in the United Kingdom

In order to gain a better understanding of the context of this thesis, we believe it is important to introduce the academic setting in the United Kingdom (UK) and the underlying dynamics of working within science. Further, we find it important to highlight some attributes of the educational system in the UK, which may have an influence on the fare of researchers within biology. Thus, this section will go through female academics in the UK and more specifically their representation in science, technology, engineering and mathematic (STEM) fields. Further, this section will briefly touch upon the "leaky pipeline" – the falling out of women along the academic career track - and obtaining a PhD. Lastly, we will look at a few of the initiatives promoting equality.

2.1 Female Academics in the UK

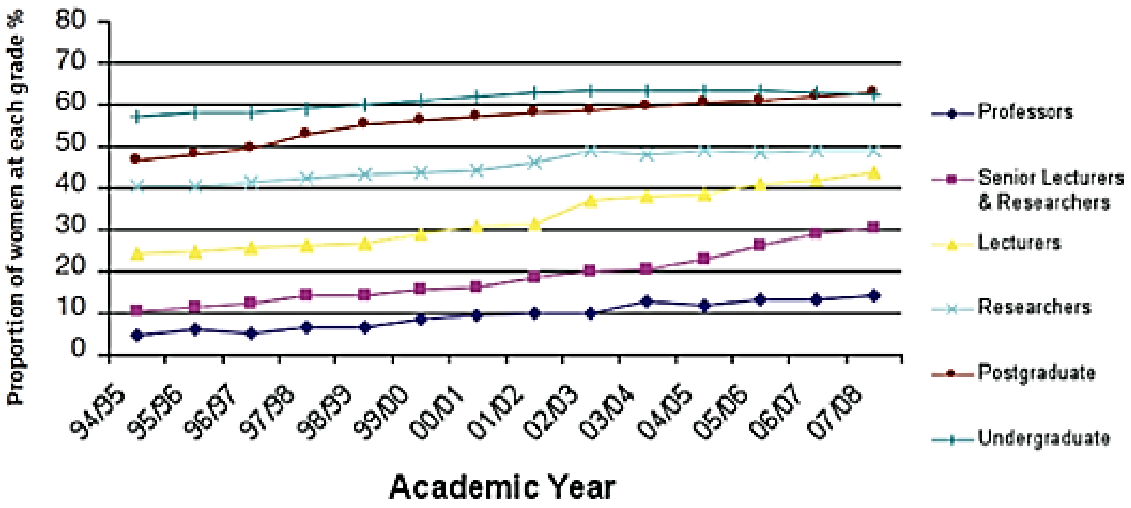
The UK provides an interesting case in which to explore the differences in productivity and performance between male and female academics. Many suggest the UK to lag behind other countries when it comes to female representation in science and engineering (Etzkowitz et al., 2003).

Although the number of female academics has increased in the last decades in the UK, women continue to be strongly outnumbered by men. Overall, of 17,880 academic staff, employed on a contract level described as professors in 2012, women only represented 21.7% ("HESA", 2012/2013). Looking deeper into the statistics, it is clear that women in the UK occupy more of the "teaching only" positions, while men make up a bigger proportion of the research staff. This is especially so within the part-time staff. Within research, more women are employed part-time than men, who tend to dominate the full-time positions ("HESA", 2012/2013). Female UK scientists clearly differ from their male counterparts in terms of time spent teaching and doing research. Women on average spend more time teaching than conducting research, while men spend more time on research. Furthermore, when men do teach, they are more likely to teach at doctoral level, whereas women mainly teach undergraduate -and master level students ("Universities UK", 2010).

2.2 Science, Technology, Engineering and Mathematics (STEM)

Earlier studies have shown that women tend to be concentrated in the softer sciences, while they form a minority in the harder sciences referred to as STEM. Within STEM, biology is the field that has the highest proportion of women (Tartari & Salter, n.d; Etzkowitz et al., 2003, chapter 1). In the UK, women also form a minority, as they only make up 17% of professors within STEM (“House of Commons”, 2013/14). Evidently, men make up a very large proportion of the faculty within STEM. As this has historically been the case, the environment within STEM has been said to be very male dominated and tough for women scientists to work in. This results in women dropping out of science as the seniority of employment increases. Looking specifically at biology, graph 2.1 below shows the proportion of women in various academic positions within biology in the UK (“RCUK” 2009).

Graph 2.1 – Proportion of females at various levels in biology in the UK.



Reproduced from RCUK (2009)

As evident from the graph, the proportion of females in various positions has increased. The graph reports the development from 1994/95 till 2007/8. However, although having increased from about 5%, the proportion of female professors is still fairly low at around 15% in 2007/8. By comparing the different positions, represented by each line in the graph, it is evident that women withdraw from science at each level of the career ladder. This is also known as the “leaky pipeline” which will be described in a moment. Due to, amongst other the leaky pipeline, we see more women in low rank positions than in high rank positions. Undergraduate females make up the largest proportion of women in science, while the proportion of postgraduate females is a bit lower. The proportion of women decreases further, when looking at researcher positions, and much further when looking at lecturer positions. Lastly, for senior lecturers and researchers, women make up a very small proportion of the total staff.

2.3 The Leaky Pipeline

The graph suggests that women fall out or voluntarily withdraw from science as the rank increases. In order to understand why this is so, one must go back to the schooling of young boys and girls. The pipeline has been used as an analogy to describe the scientific career track from elementary school to employment. The passage through the different transition points in the pipeline represents the flow into scientific careers. For women, the pipeline leaks at every joint along the way. This means that the pipe begins with a large surge of young hopeful women, but ends up with only a few women prominent enough to occupy high level positions at major universities, such as dean or department head (Etzkowitz et al., 2003, chapter 4).

The structure of the educational system is partly to blame for the leaking out of female students. According to Etzkowitz et al (2003, chapter 4), the way education in STEM fields take place seems to be a test of the characteristics traditionally associated with “maleness” in Anglo-Saxon countries. Within these countries competition, challenge and hardness have been, and to a certain degree still are, central to the daily conduct of doing things. Women are not as accustomed to the rigors of competition as men (Etzokowitz et al., 2003, chapter 4; Vasil, 1996). Thus, even though the women might be highly motivated and have the ability, they are pushed out of the career pipeline, because they are not used to the ‘male’ culture. They do not know how to behave and respond, nor how to promote themselves without being frowned upon for their behavior. This forces women either quit or to act as men and learn how to compete as men. Men on the other hand can more easily familiarize with the rules of the game. Essentially, women seem to be asked to behave in ways that are contrary to their nature (Etzkowitz et al., 2003, Chapter 4).

2.4 PhD in the UK

Compared to other countries, getting a PhD in the UK is rather fast tracked. Typically it takes four years in the UK as opposed to other countries, e.g. in the US where it may take up to six or seven years (“Study in England”, 2014). However in other countries it is more common to do a PhD on a part-time basis. Further, in the UK it is not a requirement to have a Master’s degree before initiating a PhD. However, some will chose to do a Master’s in order to prepare for the PhD program (“Study in England”, 2014). A PhD in the UK also differs because PhD’s are offered as studentships, which resemblances an ordinary full-time job. This also includes that the PhD students are funded by a specific grant for a specific period of time. Thus, the students usually know how long it will take from beginning the program till they are awarded their degree. Consequently, if the PhD is not completed by the time the grant runs out, there might not be more resources to support the PhD student to finalization (Etzkowitz et al., 2003, chapter 4).

In a 2006 study by the Higher Education Funding Council it was found that most of the full time PhDs in the UK are within the fields of biology, physical sciences, or engineering (Shepard, 2007). The study also found that the subject of the PhD is an important factor in determining whether the student finishes on time. In relation to that, it was found that PhD's within biological sciences take less time than PhD's within other fields.

2.5 Promoting Equality

To represent the interests of women, female scientists are attempting to organize themselves. This has amongst other led to a number of committees and groups such as WISE (Women into Science and Engineering) and the Athena SWAN Charter. Established in 1984, the aim of WISE is to inspire and encourage girls to consider careers within science and engineering. Today, WISE still aims to reduce the gender imbalance in the UK within the STEM workforce. Their goal is to increase the presence of female employees to 30% by 2020, up from 13% today (WISE webpage).
The Athena SWAN Charter is a very comprehensive scheme aimed at improving academic STEM careers. Founded in 2005, it is run by the Equality Challenge Unit, which works to support diversity and equality for staff and students within higher education in the UK ("House of Commons", 2013/14). Athena SWAN has six charter principles, which any university must accept and promote in order to become a member. These principles all revolve around gender equality. Once a university is a member, they can submit for Athena SWAN Charter recognition awards at bronze, silver, or gold levels. At present time, the awards are voluntary. This is believed to be a reason for their success, as the voluntary aspect appeals to the sense of competition of academics ("House of Commons", 2013/14, p. 16). It has been discussed whether to make the SWAN awards mandatory. This would mean that universities would have to get a SWAN award in order to achieve funding. However, at present time it has been argued that it would be too heavy a burden for universities, and that it would preclude parts of the university system from applying.

3. Theoretical Foundation

Before we investigate gender differences and the role of social capital in academic productivity, it is necessary to build a theoretical foundation by more specifically defining productivity and social capital, and the different aspects of the two concepts. In addition to the concept definitions, it is necessary to review what previous literature has found about the concepts. This section will first give an overview of the literature covering aspects of productivity within academia. Subsequently it will review the existing literature on social capital and its relations to gender differences and productivity. Finally, based on the literature review, the overall hypotheses are presented.

3.1 Productivity

This section will firstly introduce the definition of productivity. Secondly, the importance of productivity will be described, and thirdly, measurements of productivity will be introduced. Finally gender differences relating to productivity will be reviewed.

3.1.1 What is Productivity in relation to Science and Academia?

Technically, productivity is seen as a measure of the amount of output per unit of input (Salaran, 2010). Depending on the context, productivity can be defined in many ways. For example, it is possible to define –and assess productivity for a factory, a person, a machine, a department etc. The practice of using productivity as a performance indicator has been a focus of industries and scientific fields for a long time. The concept of productivity has also been applied to science for centuries. The development of scientific productivity also brought with it methods for both defining -and measuring academic productivity, which we will see in the following section.

According to Godin (2009) the concept of scientific productivity has taken place through four stages. The first stage was *productivity as reproduction*. This stage included statistics on science that was conducted in order to shed light on the widely discussed decline of civilization and race in the 19th century. Thus, the science was done to promote the progress of civilization, and the statistics of reproduction across nations, states and cities were used to contribute to the advancement of science. The second stage assessed *productivity as output*. In the beginning of the 20th century, the meaning of scientific productivity began to change. Psychologists started to imitate what was seen in reproduction statistics. Thus, they introduced the measurement of academic –and scientific productivity. More specifically they measured the number of articles published, in order to measure the advancement of psychology. They used the statistics to demonstrate psychology's relevance and status as an accepted academic field of science (Godin, 2009). The method of measuring output based on the number of articles is also known as bibliometrics. Later on, the Science Citation Index was developed in order to assess the impact -and influence of publications, more specifically by measuring the number of inventions and/or patents (Godin, 2009). During the 1920s, the third stage started assessing *productivity as efficiency*. Academics were no longer the only ones conducting statistics of scientific productivity. Firms started conducting research, wherefore industrial organizations and governmental bodies began to investigate firms' R&D expenses. Funding required that firms earned a profit and that the system of science could prove that they were operating efficiently. The fourth and last stage took place during the 1930s and assessed *productivity as outcome*. This meaning relates to getting the "right value for the money". It was introduced to measure the actual impact of scientific productivity further down the chain. Measuring productivity, as outcome would for example include looking into whether jobs were created from scientific advancement. However, it was acknowledged that measuring impact, e.g. by measuring change of employment, was not possible to isolate in one measure. Thus, the measurement is more indicative than conclusive.

In relation to academic productivity, Godin's (2009) second use of productivity (*productivity as output*) is the most relevant definition and measure, which will be used throughout this thesis.

3.1.2 Why is Academic Productivity important?

In order to work in academia, it is mandatory to produce publications. Measuring research productivity is traditionally based on an assessment of academic performance. This makes productivity important for the advancement and tenure of academic scientists, as universities and institutions are more likely to select the most productive scholars (Cohn & Farrington, 2014). Thus, productivity and publications are important because they are the avenue for promotion and recognition. Higher education has become a market for prestige, and the competition for tenure is getting fiercer by the day (Barnard-Brak et al., 2010). Publications are no longer just a sign of prestige and performance, but have also become a sine qua non for obtaining funds, general resource allocations and rewards and selections to scholarly societies (Ramsden, 1994; Barnard-Brak et al., 2010; Cohn & Farrington, 2014). Given that funding is important for productivity, and productivity is important to obtain funding, the academic scientists seem to work in an environment of reinforcing mechanisms, which only adds to the importance of measuring research productivity.

Lastly, science involves a system of communication, participation, interaction and exchange of knowledge and information (Fox, 2004). Thus, science is a social process that requires collaboration and therefore certain social process skills. Because research findings are communicated through publications, publications are important to exchange knowledge and get recognized, and consequently broaden one's social network (Fox, 2004).

3.1.3 How is Academic Productivity measured?

As touched upon above, academic productivity can be measured in terms of quantity (actual count of publications) and/or in terms of quality (impact, e.g. citations or patents). Furthermore, research productivity can be measured on different levels. For example, it is possible to assess productivity on the institutional level and the individual level, depending on the level of analysis (Godin, 2009). Harris (1990, in Ramsden, 1994) makes a distinction between four dimensions of research performance. These dimensions are *impact*, *quality*, *importance* and *quantity*. The four dimensions cover different aspects of productivity, and bring forth different implications. However, Ramsden (1994) solely uses quantity, as he believes that both importance and quality are subjective measures based on evaluations made by e.g. experts.

Because productivity can be defined and/or assessed differently across fields, research scholars have used various ways of measuring productivity. Although most literature in general assesses academic productivity based on the number of articles or publications in total, others include the level of professional services provided, such as mentoring or advising students. Citations, awards and patents are mainly used as indicators of quality of productivity and professional services (Duffy et al., 2008). However, as already indicated, it has been argued that the number of publications is the most appropriate way of capturing research performance, and that the number of citations (and patents) has become an appropriate measure of impact and hereby quality (e.g., Kelchtermans & Veugelers, 2013; Leahey, 2006; Bird, 2011; White et al., 2012; Lee & Bozeman, 2005.).

Issues with scientific productivity measures: Several scholars have questioned the validity of using just the number of publications to measure productivity. For example, they question whether books are included in the publication count or merely journal articles; whether the number of co-authorships is a valid measure of productivity, and so forth (Ramsden, 1994). Researchers' different applications and measurements of productivity highlight important practical implications for when comparing research findings on productivity, and for evaluating researchers and hereby determining the path of their careers. This issue of measuring productivity will be discussed more specifically in the discussion and limitations, and within the context of this paper.

3.1.4 Productivity and Gender Differences

During the last 40 years, several researchers have found that within science men are more productive than women, also implying that that women publish fewer articles than men. Even though the gender gap evidently is narrowing, gender differences still seem to exist within productivity and the advancement opportunities within science (e.g. Barbezat, 2006; Etzkowitz et al., 2003; Kessler et al., 2013; Vasil, 1996; Fox & Colatrella, 2006; Winslow, 2010). Because productivity leads to promotions, funds, recognitions and so forth, diving into –and understanding why gender differences in productivity exist, and how these differences affect women's advancement in science is very important.

In the following sections, it will be seen that literature has offered several reasons and explanations for gender differences within science and productivity. Although many researchers have found that women publish less than men, some find that the opposite is true, or that there are no differences between genders at all. In short, the problem of gender inequality is multifaceted and seems to be caused by a variety of factors and mechanisms, which the following will attempt to cover. This section will show that family and caring responsibilities are some of the primarily used -and most intuitive explanations for why we see gender differences in productivity. Other researchers have found that gender differences stem from differences in research funds, differences in self-confidence, and differences in beliefs, values and ways of doing things. Some argue that it is a matter of barriers created by structural and institutional conditions, and that institutions are responsible for developing and promoting faculty equally. The literature review will also show that women and men allocate their time differently, and have different preferences regarding teaching versus researching activities, which arguably cause gender differences in productivity. Furthermore, experience and time effects are argued to affect productivity, and lastly collaborations and co-authorships have been found to facilitate productivity differently between men and women. In order to get a better overview of existing literature's findings on –and reasons behind productivity and gender differences, the following section will outline the aforementioned explanations offered by prior research in more detail.

Family –and marital characteristics: One of the most intuitive explanations for the gender differences in research productivity has been an uneven distribution of family caring responsibilities and/or marital status. Several studies have investigated whether having children, being married or having other caring responsibilities affects research productivity. However, the studies yield different results and implications, leaving the topic open for discussion.

In their analysis of children's effect on productivity amongst linguistics and sociologists, Hunter & Leahey (2010) find that research productivity declines following the birth of a child. Thus, children, and in particular pre-school children, affect productivity negatively. Men's productivity is also negatively related to having children, but the impact is not nearly as large as for women. Additionally, men have more citations per publication than women. Children were found to have different effects on women and men's citation patterns. For example it is found that men's citation growth rate is higher than women's, and increases over time (albeit a temporary, initial decline in productivity due to children). The same pattern is not observed amongst women, which leaves Hunter & Leahey (2010) inclined to believe that network effects and men's confidence in promoting themselves explain this result. It is worth noting that Hunter & Leahey (2010) focus on softer sciences, because they believe that women have been more integrated in these fields than in harder sciences, such as mathematics and engineering.

In a more recent study, Misra et al. (2012) investigate time allocation amongst faculties at research-intensive institutions. They find that all faculties in their survey acknowledge and believe that research productivity is the most important and valued activity. Albeit this belief, Misra et al. (2012) find that mothers of young children sacrifice time to do research in order to parent instead. However, although sacrificing their research, women manage to maintain the level of teaching and mentoring from before having children. Maintaining the level of teaching and mentoring arguably ensures that fewer people are directly affected by women having children. Unfortunately, the choice negatively affects women's productivity when measured solely by number of publications. The study also finds that the women, who have already sacrificed research time, in general take on a larger percentage of the household -and caring responsibilities than men do. Misra et al. (2012) argue that these inequalities are not merely due to individual choices, but also due to structural issues that reflect gendered families and organizations. This implies that there are gendered expectations around household –and caring responsibilities, professional work, and research, which negatively affect women's productivity.

Both Gupta et al. (2005) and Etzkowitz et al. (2003, chapter 10) describe women's ever-existing conflict between the biological clock and the tenure clock. For women, prioritizing family seems like a virtue. Therefore a significantly lower number of women participate in the race for tenure, which is also evident in the lower proportion of women in high-rank positions than in low-rank positions. Women also tend to view their husbands' careers as more important than their own. Thus, women limit their own ambitions to accommodate to the family's needs.

Vange et al. (2005) find that women in research-oriented departments are less likely than women in less research-oriented departments –and men in general, to be married/partnered and have children. Furthermore, women in research oriented departments produce more than women in less-research oriented departments, which will be touched upon later in the literature review. Vange et al. (2005) suggest that women, who work in research heavy departments, where productivity presumably is higher than less-research oriented departments, deselect children in order to focus on research productivity.

In contrast to Hunter & Leahey (2010) and most literature, Fox (2005) finds that women with preschool children are more productive than women without children, whereas children do not affect men's productivity at all. However, Fox (2005) highlights that the women in her sample already have overcome a severe and hard process of scrutiny, selection and evaluation, which may skew her results positively. Fox (2005) also finds that women who are married (and live with their spouses) produce more than women who have never been married or are divorced or separated. Women in e.g. second or third marriages produce more than non-married women, suggesting that subsequently married women find new spouses that they have more in common with in terms of occupation. Men who have never been married were found to have the lowest productivity amongst men. Additionally, 59% of the women in Fox's study are married to scientists, whereas only 17% of the men are married to scientists. This suggests that being married to a person with similar occupational interest facilitate support and possibly immediate feedback, which affect productivity positively.

***Teaching-orientation versus research-orientation*:** Several researchers have argued that productivity differences can be explained by different preferences towards teaching and researching. Some of these studies suggest that working in teaching-oriented departments leaves less time for research, and hereby affect publication productivity negatively. Along with this, others suggest that working for a research-oriented department increases productivity. In addition to these findings, gender by nature has been argued to exhibit different preferences towards research and teaching. As we will see, some researchers believe that women are social by nature and therefore prefer teaching activities, whereas men are data-focused and therefore prefer research activities. Furthermore, researchers have suggested that resources are limited in teaching-oriented departments. Fewer resources mean lower productivity. To sum up, researchers have explained teaching -and research differences with a situational version, i.e. the particular department's orientation towards research and teaching, and a more biological and/or deliberate explanation, i.e. the genders' natural preference or actual choice to either teach or research. Lastly, the orientation of the departments and/or gender also has implications for the resources allocated to research. The following section will dive deeper into the literature behind these explanations.

In her cross-disciplinary study, Bird (2011) finds that women publish fewer articles than the proportion of faculty they represent. It is suggested that women tend to take on less research-oriented jobs, which may explain their lower productivity. On another note, Bird (2011) more optimistically suggests that women's lower productivity may be because women find more innovative ways of communicating and spreading their research findings. Finally, she believes that there are departmental specific factors that influence publication productivity, such as having a critical mass of women to act as role models and hereby boost productivity.

Based on an extensive literature review, Hesli & Lee (2013) also find that women publish less than men. In accordance with Bird (2011), Hesli & Lee (2013) suggest that women are more often hired into departments with fewer resources to facilitate research, and that women tend to prefer less-resource requiring activities such as teaching. Although teaching activities may cannibalize time left for research, Hesli & Lee (2013) find that two sub-activities of teaching, mentoring and advising students, actually increase productivity. It is suggested that the constructive feedback process gained from such activities facilitate productivity and increase opportunities for co-authorships. Given that there is no clear-cut explanation behind women's lower productivity, Hesli & Lee (2013) in alignment with previous literature and with the explanations mentioned above, suggest that productivity is affected by the fact that women bear a larger burden of household activities then men do.

Winslow (2010) investigates time allocation differences between male –and female faculty across scientific fields. Like the literature already described, Winslow (2010) finds that women prefer spending a larger percentage of their workweek on teaching rather than conducting research. Interestingly, she finds that women tend to spend more time on research than they actually prefer. Winslow (2010) suggests that this may be explained by women's lower likelihood of obtaining promotions; therefore women are less incentivized to focus on research because it does not pay off as well as for men. On the other hand, Winslow (2010) finds that institutional factors shape gender preferences, and therefore suggests that gender differences instead may reflect institutional constraints in women obtaining positions comparable to those of men. Thus, there may exist a higher internalized teaching bar for women and a higher research bar for men. Winslow's (2010) findings may suggest crucial implications given that time spend on research is positively related to productivity and hereby also advancement.

Vange et al. (2005) examine gender's influence on success by focusing on early research productivity of a group of tenured faculties, who have already survived the first obstacles of their academic careers. They find that women's productivity is more affected by department-orientation, i.e. whether they work in a research-oriented -or less research-oriented department. Men's productivity barely varies across the departments' orientations. The findings highlight an important question of whether research-oriented departments require more effort from women than from men to prove their worth. Given that previous research suggested that women prefer working with people, and to nurture and be caring, the findings of Vange et al. (2005) may also suggest that women self-select into less research-oriented departments, where social interaction is a bigger part of the job. This argument is also supported by Kessler et al (2013), who find that women are more satisfied with their jobs when working in teaching-oriented departments, whereas men report higher satisfaction working in research-oriented departments. The finding has important implications for gender equality, since research-oriented universities tend to pay higher salaries than teaching-oriented universities. If teaching –and research preferences are biologically determined, there should be no problem. However, if the differences in preferences are based on how women have been (dis-)encouraged throughout their lives to take on more people-oriented careers where they earn lower salaries, then there is an issue that needs attention.

In accordance with prior studies Ceci & Williams' (2010) also find that women tend to work in teaching-oriented departments with limited resources, which in turn affects productivity negatively. Thus, Ceci & Williams (2010) argue that resources are crucial to productivity, and that the issue of gender differences is a matter of redirecting resources. Interestingly, they find that women occupy the positions with fewer resources because they chose to, due to family, lifestyle –and career preferences. However, in line with Kessler et al. (2013), Ceci & Williams (2010) argue that if women's choices are freely made and they are satisfied with the outcomes, then there is no problem. However, if the choices are constrained by biology and/or society, and women are dissatisfied with the outcomes, or women's talent is not realized, then there is a serious problem.

***Individual/personal and institutional/situational factors*:** As already suggested by Vange et al. (2005) above, studies have explained productivity differences between women and men based on institutional -and individual factors. The findings from these studies resemble each other. The literature suggests that some influencing factors are external and beyond the control of the scientist, whereas other factors are personal and unique to the individual. Furthermore, the university environment, especially within the STEM fields, is described as male-dominated and as built on the foundation of male-oriented values (Kamerade, 2007; Stack, 2002; Black & Holden, 1998; Etzkowitz et al., 2003; Creamer, 1999). This has arguably left its traits on today's institutional environments and may affect the gender conflict existing within science and academia.

In their study of what makes a research star, White et al. (2012) argue that the individual factors that increase productivity are the possession of better time management skills, a higher probability of attaining promotion to high rank positions, and finally a genuine interest in research. Of the situational factors, White et al. (2012) find that highly productive researchers are more likely to have research support e.g. from graduate assistants and summer research support, in general have more time available for research and fewer course preparations, and finally are more likely to work in departments that prioritize research over teaching.

Ramsden (1994) investigates what kind of environmental factors facilitate –or stall high research productivity. In thread with White et al. (2012), Ramsden (1994) develops a theoretical framework that explains research productivity with personal (individual) and structural (situational) factors. He finds that the strongest *personal* factors that facilitate productivity are an early interest in research, being involved with research activities, and seniority of academic rank. The strongest *structural* factor that facilitates productivity is working in highly research-oriented departments. Additionally, Ramsden (1994) finds that a cooperative management style is associated with higher individual productivity, implying that involvement in organizational related planning –and decisions is important. Lastly, he finds that dissatisfaction with the promotion system is negatively related to productivity. According to his findings, neither gender nor age relate to productivity.

In their interview-based study of what factors influence women’s participation, performance and advancement in science, Fox & Colatrella (2006) finds that research –and teaching autonomy (intellectual autonomy) affect women’s participation in science. Additionally, being able to choose research questions and the opportunity to contribute to existing knowledge that will influence following generations are important factors regarding participation. Curiously, Fox & Colatrella (2006) find that only few of the women interviewed defined success in terms of publishing articles, obtaining tenure and developing curriculum. Although Fox & Colatrella (2006) do not report how the women instead define success, women’s definition of scientific success may arguably be more unconventional. This might suggest that women publish less due to different (unknown) success criteria. Regarding advancement, Fox & Colatrella (2006) find that women are unclear about the attributes needed to advance in science. Furthermore, the women in their study find that the attributes needed to get promoted to full professors, compared to associate professors, are subjective, biased, less known and less understood, and to a certain degree out of the candidates control.

In their study of female researchers’ career prospects in Swedish universities, Danell & Hjerm (2012) find that women are less likely than men to advance to professors, and that it seems sensible to assume that factors *within* the universities affect women and men’s career trajectories differently.

More specifically, they argue that knowledge of women's early career events create a better understanding of the reasons behind the later found gender differences. Danell & Hjerm (2012) find that women and men fare equally well when their careers are initiated in a meritocratic way, i.e. when people are selected based on talent and intellectual criteria such as post-doctoral positions. However, they believe that Swedish universities do not fully apply meritocratic approaches to advancement, which is a problem to women's fare in academic science.

Barbezat (2006) finds that gender is not a predictor of productivity. Rather, it seems to be caused by institutional factors and the specific job types. Barbezat (2006) also suggests that the years of experience, time devoted to research versus teaching, marital –and parental status, department rank as well as professional presentations and publications all correlate with productivity. Thus, Barbezat (2006) emphasizes that there is not one single cause for women's lower publication productivity, and that we must look at the bigger picture.

Funding**:** Although talent and skills ought to be key to productivity and advancement, several researchers have found that research funds are unevenly distributed amongst men and women. Larivière et al. (2011) analyze funding amongst professors from Québec University. They find that women receive less funding -and produce fewer articles than men. Furthermore, women receive fewer citations on average than men. Men's funding rates increase until they reach their fifties. However, women's funding rates grow at a slower rate and never seem to reach similar levels as men's. Women's lower funding rates negatively affect productivity, and results in a negative feedback loop. Thus, when women receive less funding, their scientific research is reduced. This subsequently reduces the number of publications, which again results in less funding. Larivière et al. (2011) also find that women in senior positions are less likely to direct research teams, which may be caused by their lower rates of funding. However, it is suggested that other factors than funding affect productivity. Hereby Larivière et al. (2011) questions the validity of their own findings, and the extent to which funding is a main explanatory factor for women's lower productivity. For example, they suggest that marital -and parental status, networks, and rank of the university influence productivity.

Fox (1991) also find that women receive fewer funds to conduct research than men. Fox concludes that men and women receive funding and grants according to their number of submitted proposals.

If women receive less funding, they have fewer resources to conduct research. Therefore they also submit fewer proposals, which cause them to produce less. It is a vicious circle as also found by Larivière et al. (2011).

***Gender schemas and self-confidence*:** Studies have shown that stereotypes and gender schemas may have an effect on the gender differences we see in science. Gender schemas hypothesize what it means to be a woman, and what it means to be a man, i.e. the specific behaviors we expect genders to exert. Accordingly, men are supposed to *act* and be task-oriented, while women are supposed to feel, nurture and care. The following will review some of the literature covering the topic of gender schemas and will also dive into the suggested effects arising from self-confidence or a lack of the same.

Literature has found that women are cited less often than men. This is suggested to be due to the Mathilda effect, whereby women's contributions are undervalued per default and often attributed to male colleagues instead (Larivière et al., 2011). It is also suggested that the Mathew effect is part of the problem. The Mathew effect means that the rich get richer and the poor get poorer, i.e. the researchers already much cited get cited even more. Both the Mathilda –and the Mathew effect are examples of gender schemas and can cause barriers to the performance and advancement of women in science (Etzkowitz et al., 2003).

In her article, Valian (2004) finds that gender schemas result in devaluation of women, whilst men are subjects to the reverse. Valian (2004) argues that gender schemas affect perceptions of competence, and therefore make it difficult for women to accumulate the benefits of their achievements. Additionally, it challenges the possibility of women being perceived as competent leaders. Previous research has also shown gender schemas in which both men -and women respond negatively to women who exert a friendly but confident leadership style, than to men who adopt the same style. This makes it even more challenging for women pursuing high-rank positions, and questions the usefulness of relying on female role models in preventing gender discrimination. Furthermore, it illustrates a counterintuitive problem; namely, women acting as barriers to women who strive for advancement and development (Etzkowitz et al., 2003).

Social self-efficacy and gender differences may have an effect on career advancement as well (Vasil, 1996). Self-efficacy, i.e. confidence, is needed in order to overcome the barriers that cause gender differences. Vasil (1996) finds a significant difference in women and men's confidence and their beliefs in their own social-process skills. Men feel more confident in negotiating and promoting themselves and their work, as opposed to women. Women feel less confident -and are unaware of how to play the game. Given that women tend to be in lower-rank positions, they also suffer from a lack of power in which they potentially could utilize self-promoting -and negation skills. Hereby, social process skills and the lack of the same influence women's career advancement. It is interesting to note the potential reciprocal and reinforcing effects of, in this case, self-efficacy and productivity.

Position rank and years of experience**:** Another seemingly intuitive explanation behind gender differences in productivity is the rank of position and experience in terms of years. In her exploration of gender's effect on productivity, Creamer (1998) finds that when controlling for productivity, gender differences exist in remuneration, resources, tenure, and rewards. This suggests that women receive less recognition than men. More specifically, senior scholars often are persons whose resources and job tasks has coalesced and created cumulative advantages. Women also tend to suffer from a lack of engagement in networks outside the institutions. This results in women being more dependent on the institution's internal reward structure in terms of facilitating productivity.

Measured by the number of citations -and articles published, Kelchtermans & Veugelers (2013) find that women are less likely than men to reach top performance within research productivity during their early career years. However, once women reach top performance, they benefit significantly more from the accumulative advantages, which in effect help them sustain top performance. This is not the case for men, whose performance seems to stabilize once top performance is reached.

D'Amico et al. (2011) find that productivity differences are caused by structural factors, such as department size and rank. In their study of Italian psychology faculty, they find that significantly fewer women get tenured to full time professors. On the contrary, women occupy the majority of lower-rank assistant positions. In reverse, men take up majority of high-rank positions. The fractions of women who have gotten tenured are fewer in medium/large departments, whereas women take up majority of small departments. In similar veins as Kelchtermans & Veugelers (2013), D'Amico et al. (2011) also find that men only publish more than women during pre-tenure stages. Once women attain senior positions, their productivity increases; a pattern not observed amongst men. Thus their findings indicate a delayed improvement of women in academia albeit still being underrepresented amongst full time professor -and higher ranks.

Although it is often assumed that promotions result in productivity, Mauléon & Bordons (2006) find that it is the other way around; namely that productivity leads to rises in rank. This is the case for both men and women. In alignment with previous studies, Mauléon & Bordons (2006) find that women tend to occupy a majority of low-rank positions, and are barely represented in high-rank positions. If productivity relates to rank, Mauléon & Bordons (2006) believe that it is obvious why women publish less than men. They do however also suggest that women and men have different productivity life cycles. Thus, women's lower productivity is either due to a lower presence in higher ranks or due to their present phase of the productivity life cycle. Furthermore Mauléon & Bordons (2006) finds that women in academia are on average younger than men. Black & Holden (1998) also find that men in academia on average are older than women – and have worked for more years. Men are more likely to get tenured and earn higher salaries, whereas few women get tenured to professors or become leaders. Although fully rejected by Mauléon & Bordons (2006), Black & Holden argue that because men have been in science for more years than women, men in effect occupy majority of high-rank positions. However, Black & Holdon (1998) also believe that the situation is improving, i.e. that men and women who have entered academia in more recent decades are less subject to gender-based treatments.

***Specialization*:** Much in relation to having a genuine interest and passion for a research topic, research has also found that specialization in research topics affect productivity. Leahey (2006) argue that while gender differences in salary, grants, and promotion largely can be explained by productivity, we firstly need to understand what causes the differences in productivity. Leahey (2006) investigates how gender affects the degree of research specialization, and how research specialization affects productivity. The findings indicate that specialization plays a critical role in explaining productivity. It is found that men tend to specialize more than women. According to Leahey (2006) men specialize because they believe that diversifying will be perceived as failure to excel in a given research area. By failing to specialize, women forego opportunities to increase productivity. However, Leahey (2006) finds that men have wider -and more diverse networks which may imply that men have an easier time finding collaborators with whom interests overlap. This arguably means that men more often reinforce each other's expertise, and receive feedback. This in turn affects performance and productivity positively. As opposed to men, women have smaller and more homogenous networks (Larivière et al., 2011). This means that women need to branch out in other research topics in order to find collaborators. This has constraining effects on the degree to which women can specialize.

***Collaborations, co-authors and networks*:** In their 2005 study, Lee & Bozeman set out to test the assumption that collaborations positively affect productivity amongst scientists. They believe that collaboration is more often assumed to increase productivity than it is actually proven. Contrary to their belief, they do find a strong relationship between collaboration and productivity, whether including or excluding the influence of other variables, such as age, academic rank, and grants. Thus, their research confirms the aforementioned assumption. They do however note that the exact quality of the productivity is not proven. Lee & Bozeman (2005) argue that it is important to understand the influence of environmental –and individual factors and their role on collaboration's effect on productivity. Thus, collaboration in isolation does not necessarily increase productivity. Hereby Lee & Bozeman (2005) raise an interesting issue relevant for investigating gender differences and scientific productivity.

Fox (1991) argue that research networks can constrain or enhance productivity depending on the degree of network involvement. Involvement in networks leads to stimulation and research. Additionally, involvement in research networks results in an increase in collaboration and in men and women's number of co-authors. According to Fox (1991) co-authoring can significantly increase the number of articles published -and citations received.

Fox & Mohapatra (2007) find that collaborations within -and outside institutions are positively associated with research productivity in terms of publications. In their study, collaboration involves the pooling of ideas, skills, energy and time, from which productivity increases. Fox & Mohapatra (2007) do however note that it is important to consider the reinforcing effects of collaboration and productivity, and that they cannot claim a causal relationship as such. In their study of Québec professors, Larivière et al. (2011) find that men collaborate more with externals and suggest that men have much wider (international) networks to utilize for productivity.

On the contrary to Larivière et al (2001), Stack (2002) finds that gender is unrelated to productivity. In his study of sociologists he finds that women in softer sciences such as sociology are much more integrated than women in hard science, such as mathematics and biology. Stack (2002) believes that unlike many sciences with a small proportion of women, women sociologists have developed more extensive research networks, which facilitates their productivity, as also suggested by Fox (1991). Stack (2002) argues that the number of co-authors can be used to assess the degree of network integration. In alignment with Stack (2002), Stvilia et al. (2010) find that gender alone cannot explain productivity. Instead, disciplinary diversity in teams significantly affects productivity positively. Additionally, low differences in team members' seniority facilitate productivity. Specifically Stvilia et al. (2010) find that an increase in the proportion of senior members on a team has a negative impact on productivity.

In an interview-based study, Creamer (1999) explores productivity when scientists collaborate with spouses and partners who also work in science. Collaborations with spouses and partners facilitate constructive feedback processes, which positively affect productivity. Thus, productivity in this case seems to be facilitated by the direct access to intellectual, specialized –and emotional capital arising from collaborating with a partner or spouse whose interests overlap with one's own. Creamer's (1999) findings emphasize the importance of trust, proximity, overlapping skills, and informal feedback on a long-term basis. The findings have several implications for today's information –and communication technology-based collaborations. According to Creamer (1999) academics must challenge intellectual isolation and focus on interacting with colleagues from their departments and universities.

As can be derived from the above, networks and social capital are important for productivity. Therefore, the next section will dive into the concept of social capital.

3.2 Social Capital

During the second half of the 20th century scientists and researchers have gradually moved away from solo authored articles towards co-authored articles. The development has taken place alongside the trend of research moving away from being mainly conducted by the lone scientists, and into team-and group collaborations. Within science, such collaborations today have become the rule rather than the exception (Stvilia et al., 2010; Etzkowitz et al., 2003). Today's social nature of research conduct requires being able to socialize in order to perform and succeed under the collaborative conditions (Etzkowitz et al., 2003, chapter 2 & 8). The trend of working in teams, collaborating, and co-authoring has prompted researchers to look into the effects of social capital on performance and productivity.

The following will go in depth with the theory and literature behind social capital. However, we will first briefly go through network theory, as we believe this forms the base for understanding social capital theory. Next, we will look into the origins of social capital, before going into describing how social capital is defined, used and measured. Lastly, we will look into how social capital relates to productivity and gender differences.

3.2.1 Understanding Social Capital through Network Theory

Although not the main focus of this thesis, we will briefly go through the theory of networks, as we believe it facilitates a better understanding of the logic behind social capital. The network structures of institutions and organizations have received increasing attention in the last decades. The essence of networks is that in all organizations there exists an informal structure that runs parallel to the formal structure (Beugelsdijk & Hospers, 2006). This implies that when an employee needs to get something done, he/she will not always follow a formal manual, hierarchy or routine, but instead he/she will directly contact a colleague somewhere else in the organization. Thus, one can think of networks as facilitating a form of internal market mechanism for getting work done. In this mechanism the used assets are intangible, personal relationships, often referred to as social capital in network analysis (Beugelsdijk & Hospers in Koen, 2006).

The nature of the relationships in a network plays a crucial role in order to derive the best knowledge sharing and networking. Granovetter (1983) posits that the relationships existing within networks are based on strong or weak ties. He especially emphasizes the importance of weak ties.

Weak ties, also known as bridging ties, facilitate access to more diverse and new information, as opposed to information obtained through strong ties, such as family or close friends. Complementing the work of Granovetter (1983) Burt (1992) refers to weak ties as structural holes. A structural hole occurs when person A has a relationship with person B. Person B is further connected to person C, whom person A has no direct or indirect link to, i.e. person A is weakly tied to person C via person B. Thus, person A will gain access to a broader range of information and knowledge through person B. This means that people like person B bridge groups and clusters and hereby enhance information access -and sharing (Burt, 1992; Granovetter, 1983). This suggests that a person managing many structural holes, i.e. the broker, is in an advantageous position because he/she manages the actual information flow. Managing the information flow may potentially make the broker more likely of e.g. getting promoted, develop innovative products, and to gain power and influence (Granovetter, 1983; Beugelsdijk & Hospers, 2006).

Network analysts have found that people with weak ties are the ones who fill structural holes and have particular value in a network structure, because they complete the structure. This implies that by enabling cross-organizational interactions, linkages between earlier separated departments might arise, thus widening the possible flows of information. Where Granovetter (1983) focuses on the strength of ties, Burt (1992) focuses on the redundancy and non-redundancy of ties. He argues that redundant ties make the network more likely to survive (organizational) changes, whereas network of non-redundant ties may get distressed by this.

One large limitation of Burt's (1992) work on structural holes is that he assumes away problems of trust and reciprocity between people. Burt (1992) neglects discussing the nature of ties, but instead mainly focuses on the individual aspect of networking. Thus, Burt ignores the collective nature that roots within organizations and institutions, including the actions that support the maintenance of the network structures (Beugelsdijk & Hospers, 2006). In practice, network relations within organizations and institutions often go beyond the simple "buyer-seller" relationship. The transactions taking place in networks are often tacit. This implies that relationships within networks require altruism and trust (Beugelsdijk & Hospers, 2006). Although Burt (1992) claims that the structural hole is the most efficient position one can have in a network, an additional limitation to his work is that he neglects the importance of closure of structural holes. Closure in the form of trust and reciprocity is important for the existence of efficiency and required trust within the network (Beugelsdijk & Hospers, 2006).

3.2.2 The Origins of Social Capital

The concept of social capital arose from community studies in which the importance of strong relational networks was emphasized and claimed central to the functioning –and survival of neighborhoods. Strong networks within communities are argued to root in trust, cooperation and collective action (Nahapiet & Ghoshal, 1998). Since then, the concept has been used to study various aspects of sociology. Bourdieu, Coleman and Putman, who are considered to be amongst the main contributors to the field, have helped develop the concept into one of today's more popular areas to study (Gauntlett, 2011; Tzanakis, 2013; Portes, 1998).

Bourdieu (1930-2002) was a French sociologist who was very active within social capital research during the mid-80s to mid-90s. He defined social capital as "*(…) the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition*." Bourdieu's definition of social capital is rather instrumental, as it focuses on the advantages to the individual possessors of social capital, and the deliberate construction of sociability simply for the purpose of obtaining social capital.

Coleman (1926-1995) was also a sociologist active during the same time as Bourdieu. As opposed to Bourdieu, Coleman used social capital theory to enhance understanding of economic theory regarding economics' overly rational and individualistic models. Thus, he used social capital theory to combine the idea of the rational individual who still accounts for the development of the social collective. Coleman believed that social capital exists in many shapes, but essentially consists of *"(…) some aspect of social structure, and facilitates certain actions of actors whether persons or corporate actors within the structure"* (Tzanakis, 2013). According to Coleman, social capital facilitates individual -or collective actions caused by networks of relationships, obligations to reciprocate, trust, and social norms. In alignment with Bourdieu, Coleman's definition of social capital has an instrumental purpose because the actors in networks are goal-oriented. This implies that social capital and its inherent networks can be exploited to create something of value. Compared to other forms of capital, Coleman views social capital as unique because it is created by

–and an outcome of meaningful social relationships that individuals invest in. Whether or not the action facilitated by social capital benefits network as a whole depends on the individual who exploits the social capital (Gauntlett, 2011; Tzanakis, 2013).

In his article from 1999, Putman (1938-) defines social capital as *"(...) features of social organizations, such as networks, norms and trust that facilitate action and cooperation for mutual benefit"* (Tzanakis, 2013). According to Putman, social capital is evident in the amount of trust available –and characterizing a network. As opposed to Bourdieu and to a larger extend than Coleman, trust, reciprocity, altruism and voluntary association are important factors to Putman's definition of social capital. These factors arguably facilitate the collective value of social networks and generate feelings that make members want to do things for each other (Tzanakis, 2013). According to Putnam, social capital is key to maintain and build democracy, and it is "measured" by the amount of trust, reciprocity and altruism in the network.

Where Coleman and Putman see social capital as a fundamentally beautiful aspect of people and networks, Bourdieu is the only one among the three who emphasizes the downsides of social capital. To Bourdieu, social capital is a tool especially deployed by the elite, which operates as an exclusionary device; certain people are excluded from groups or networks. He illustrates social capital by the wealthy and powerful who use "their old boys network" (Gauntlett, 2011) or by people/groups who use social capital to maintain advantages for themselves, their social class or alike (Gauntlett, 2011; Tzamakis, 2013). Thus Bourdieu believes that social capital demonstrates how inequality in society is created. As opposed to Bourdieu, Coleman and Putman see social capital as something positive, and something that is important to develop individual human capital –and increase collective value.

3.2.3 What is Social Capital?

Since its origin, the literature on social capital has grown rapidly. However, the concept has been –and still is subject to many definitions and interpretations. Today there is not one single definition of social capital, and accordingly there is still a lot to learn about the concept. Amongst other, this has also resulted in discrepancies when it comes to social capital's level of analysis, the maintenance -and motivation for participating/not participating in social capital networks, and to whom the benefits of social capital, if any, accrues (Portes, 1999; Tzanakis, 2013).

According to Etzkowitz et al. (2003, chapter 8) social capital refers to the relational aspects of informal dimensions. Social capital facilitates information, validation and encouragement. Thus, it relates to the (productive) resources a person has access to through contacts that possess critical resources, or resources that the person creates with another person he/she has a relationship with. If the relationship ends, the value of the resources decreases or are transferred to another relationship. Social capital resources include trust and norms of reciprocity as well as knowledge of new scientific ideas and research strategies. More specifically, the characteristics of social capital are reciprocity and an increasing indebtedness that facilitates sharing of tacit knowledge or the allocation of resources to each other. Social capital also increases the speed and the veracity of the knowledge and information exchanged. Furthermore, social capital networks provide a degree of support from the other network members. The support consists of critical feedback and motivation to commit to the network. Additionally, emotional support and group affiliations are a big part of social capital network. This also facilitates the creation of identity and enhances the feelings of self-worth needed to be a member (Etzkowitz et al., 2003, chapter 8 & 12).

Nahapiet & Ghoshal (1998) define social capital as *"(...) the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit"*. Nahapiet & Ghoshal (1998) argue that social capital takes many forms, but that these forms have two characteristics in common. Firstly, they constitute some aspect of social structure, and secondly, and in alignment with Coleman, the forms facilitate the actions of individuals within the structure. Furthermore, social capital cannot be transferred easily as it resides in friendships and obligations to one another. According to Nahapiet & Ghoshal (1998) social capital increases efficiency of action, and reduces the risks associated with opportunism due to the embedded trust. This means that social capital reduces transaction costs. Lastly, Nahapiet & Ghoshal (1998) believe that social capital encourage cooperative behavior.

Grevet et al. (2010) define social capital as the *"(...) investment in social relations with expected returns in the marketplace"*. Social capital is according to Greve et al. (2010) a concept that is shared between participants. They believe that social capital facilitates four main effects. These effects are firstly getting information, secondly, transfer of knowledge, innovation and diffusion of technology or practices, thirdly combining complementary knowledge and helping to solve problems, and lastly brokerage, i.e. facilitating the exchange of knowledge and information.

The above definitions resemble the ones brought forth by Bourdieu, Coleman and Putman. Although the concept of social capital may lack consensus, the literature above seem to argue for its undeniable -and important effects. Most of the literature agrees that social capital is a resource that facilitates cooperation within -or between groups of people, and that social capital can benefit both the collective -and the individual; all agree that the benefits of social capital include the spread of knowledge and innovation, promotion of cooperation, and/or the reduction of transaction costs Across the social capital definitions there is an agreement that social capital exists in relationships, in which trust is an important factor. Whether trust is synonymous with social capital, or simply a facilitator of social capital's development, is still a subject to research. Furthermore, most of today's literature agrees that social capital includes *both* the network and the *assets* that can be mobilized through the network. (e.g. Brooks & Nafukho, 2005; Nahapiet & Ghoshal, 1998; "Productivity Commission", 2003).

3.2.4 Why is Social Capital important?

Social capital is important for several reasons. Firstly, the myth of the lonely scientist has for long been reported as obsolete. Nowadays scientific research is mostly conducted in groups of scientists across departments, institutions and country borders. Scientific developments and innovations do not only require financial –and human capital, but also social capital, in order to be successfully (Etzkowitz et al., 2003, chapter 8; Nahapiet & Ghoshal, 1998; Greve et al., 2010; Lee & Bozeman, 2005; Metz & Tharenou, 2001). This importance of social capital is also evident in today's increase in industry-university collaborations, where social ties among scientists and industries have become essential to collaboration. Secondly, a majority of scientific research proposals are based on problems that are too large for a single scientist to solve alone. Research solutions span across various fields of science, and therefore scientists need each other's different –and specialized competencies in order to proceed. Thirdly, ties (strong or weak) among scientists increase the probability of finding research collaborators with the needed competencies, same devotion and interests in the same research area (Etzkowitz et al., 2003, chapter 8). Fourthly, social capital facilitates information speed -and flow, which is useful for conducting research. The logic behind social capital networks is 'a favor for a favor'. The obligation of reciprocity makes members who use the network feel indebted and therefore ensures constant contributions to the network. Lastly, according to research, co-authored work fare better in the publication processes than solo-authored work. As a result, co-authored work arguably has higher odds of receiving funds, receiving necessary feedback and sanity checks and so forth (Fox & Mohapatra, 2007).

Within science and academia there are specific networks of elite scientists who meet regularly to exchange ideas, resources and information. These elite scientists are exposed to various areas of research and discover scientists with complementary skills with whom they may collaborate. Additionally, and importantly, the elite scientists within these networks introduce their graduate students and post-doctoral fellows to each other, and hereby create a path for advancement to the next generation of scientists. Thus, access to networks is crucial to achievement and development (Burt 1992; Etzkowitz et al., 2003, chapter 8). For example, a large network of especially bridging ties facilitates timely access to intellectual capital, which in return facilitates productivity. Hence, participating in social networks increases the level of social capital, and allows one to leverage the resources of the network in order to enhance productivity and thus advance ones career.

Researchers argue that differences in scientists' social networks influence probability of succeeding because it shapes the scientists' level of social capital. Thus, the exclusion from networks has been used to partially explain the low proportion of women in science, and to explain why the women who make it into science yield lower productivity than men. Because social capital created from network participation influence performance and productivity, social capital is an important aspect to research in order to understand productivity and the potential gender differences (Etzkowitz et al., 2003, chapter 8).

3.2.5 How is Social Capital within Academia measured?

Social capital can be measured in a number of ways depending on the context, e.g. individual, community -or societal level. Even the most comprehensive definitions of social capital seem to have many dimensions and include several levels of analysis. Thus, identifying one true measure of social capital is probably not easy or even possible. More generally, social capital can be assessed both quantitatively and qualitatively. In surveys for example, respondents can answer questions that cover a variety of topics, such as the level of trust towards colleagues, neighbors or alike, or the number of memberships in clubs or societies, and the participation and involvement in these. Another way is to study people's communication patterns with colleagues and friends, and how much social contact people have with these colleague or friends (e.g. Salaran, 2010; Reagans &

Zuckerman, 2001). A more qualitative approach is of course face-to-face interviews and/or more elaborate survey comments. For example, Metz & Tharenou (2001) measure social capital based on survey questions about mentor support, career encouragement, networks, and comfort level with decision makers and personal tactics.

Within academia and science however, social capital may be assessed differently. According to Etzkowitz et al. (2003, chapter 8) social capital provides an approach for measuring -and analyzing gender differences in research performance in a context where productivity is based on network members' dependence on each other, and their ability to manage this dependence. They assess social capital within science and academia based on two dimensions, which comprise social networks; *strong ties* and b*ridging ties* (which are similar to weak ties). Strong ties are intra-departmental and therefore involves frequent interaction, collaboration, and sharing of (sensitive) information. Strong ties require substantial resources to maintain. Bridging ties are inter-departmental, and require less frequent contact. Usually, bridging ties are based on professional acquaintances obtained through e.g. conferences and other more social activities. Furthermore, bridging ties are likely to exist between professionals from different disciplines, and require fewer resources to maintain. Therefore, the larger the number of bridging ties, the higher the level of social capital (Etzkowitz et al., 2003, chapter 12). In their own study, Etzkowitz et al. (2003, chapter 12) find that the number of weak ties and the number of co-authors correlate, and are also associated with research success. Thus, according to Etzkowitz et al. (2003) social capital can be measured based on the number of weak ties, or more specifically the number of co-authors.

Fox (1991) also believes that network activity, and hereby social capital, can be assessed by measuring the level of co-authorship and cross-gender collaborations. Although co-authorship data does not assess aspects of integration in such a complex phenomenon as networks, it is according to Fox (1991) one of the best measures available. Further, Stack (2002), argues that the degree of network integration can be assessed by the number of co-authors, as touched upon earlier in the literature review.

3.2.6 Social Capital, Productivity and Gender Differences

In order to apply social capital theory to the topic of this thesis, we find it necessary to review previous literature on social capital and productivity, as well as gender differences within social capital.

Available literature suggests a positive influence of social capital on productivity. In order to get the job done, workers and professionals need to utilize colleagues' -and others' support and competencies beyond the hierarchical structure of companies and institutions (Greve et al., 2010; Burt, 1992). However, research also shows that the degree of social capital varies between women and men. This evidently has implications for the performance and potentially the advancement of women and men in academia.

Greve et al. (2010) study the influence of human -and social capital on productivity among firms engaging in applied research and consulting. In relating social capital to productivity, it is in its nature that complex tasks are conducted in collaboration with others, i.e. under social terms. Solving complex tasks require exploiting knowledge from across disciplines. Greve et al. (2010) find that social capital is the most important facilitator of productivity, and that it contributes to productivity in two ways: one is using social relations to mobilize people to contribute to the project. The other is using team members' social capital to expand and complement the knowledge base of the team. In relation to this, Greve et al. (2010) emphasize the importance of network members' absorptive capacity, which is their ability to understand each other's knowledge contributions. Thus, although disciplinary diversity is good for innovation and results, there still need to be a minimum amount of overlapping skills and knowledge before members can make use of each other's contributions. Investigating social capital in corporate R&D teams, Reagan & Zuckerman (2001) support the findings of Greve et al. (2010). Linking social capital to network theory, Reagan & Zuckerman (2001) argue that social interactions, i.e. social capital, is needed in order to achieve better performance. In alignment with Greve et al. (2010), they emphasize the positive aspects of both closure and diversity of networks. They find that a certain degree of closure - that is, overlapping skills and commonality - is needed in order to utilize each other's knowledge and increase productivity. The implications of their findings pose a challenge to the manager of such teams, as it is easy to make a team more diverse, e.g. by removing a member and introducing new members. However, it is difficult to impose –and implement social activities, as the outcome depends on the individual personalities making up the team and how these personalities fit together (Reagan & Zuckerman, 2001).

Salaran's (2010) findings support those of Reagan & Zuckerman (2001). In his study of social capital's role in increasing research productivity in Australian higher education, he finds a significant and positive correlation between social interactions – and its frequency, and research productivity. According to Salaran (2010), social ties are channels for information and resource flows, and therefore facilitate the growth of productivity. Thus, Salaran (2010) recommends that researchers must increase communication and interaction with their colleagues and superiors across –and beyond departments, institutions and borders. Furthermore, the institutions must be designed to facilitate social activities, whilst the academics and scientists must learn to build –and nurture social ties.

In their article on the creation of intellectual capital, Nahapiet & Ghoshal (1998) describe that social capital is like a set of resources rooted in relationships. They identify three dimensions of social capital that facilitate the creation of intellectual capital. These dimensions are structural, relational and cognitive dimensions. The *structural* dimension refers to the overall pattern of the network, i.e. how the people and clusters are tied together, and the individuals' ability to create strong/weak ties. The *relational* dimension is linked to the social aspect of networks, and emphasizes the specific relations that the people in networks have, and how this influences behaviors. This dimension highlights assets leveraged in networks, such as the role of trust, norms, identity and cooperation. Lastly, the *cognitive* dimension relates to factors that facilitate a shared "language" and meaning evident through symbols, representation, interpretation and so forth. This dimension partially relates to the importance of having a degree of overlapping skills as emphasized by Greve et al. (2010) and Reagan & Zuckerman (2001). Nahapiet & Ghoshal (1998) conclude that the ability to create –and exploit social capital is an organizational advantage, and is essential to the performance, the development of intellectual capital, and furthermore the productivity. They find that the intellectual capital is deeply rooted in the social relations and that differences in performance may represent differences in the ability to create and exploit social capital.

According to Etzkowitz et al. (2003, chapter 12), men typically form closer social ties with other male colleagues, both within and beyond their departments. However, women tend to report having no close relationships with their male colleagues. In their study, Etzkowits et al. (2003, chapter 12) find that social relationships at work varies along two dimension; *colleagueship* and *reciprocation*. More specifically, they find that these dimensions of social relationships facilitate productivity. Whereas men report high levels of colleagueship and reciprocation, women report low levels of both dimensions. Furthermore, women in general participate less in networks, and have fewer bridging ties than men. This means that women obtain fewer strong and/or bridging ties than men, and therefore have less social capital (Etzkowitz et al., 2003, chapter 12). The findings suggest that the lack of social network participation -and social capital creates severe barriers to the success and advancement of women in science and academia.

As mentioned earlier in the literature review on productivity, women have to fight the biological clock and often choose to put family before their careers. Further, it has been found that some women tend to prioritize their husbands' careers instead of their own (Gupta et al., 2005). All this combined result in women foregoing chances for engaging in informal events and communication, as well as participation in conferences and so forth (Gupta et al., 2005). As argued by Gupta et al. (2005) this has negative consequences for women's social capital and networks, which are crucial factors facilitating productivity.

Because science fundamentally is a social process, Fox (2010) highlights four key social features of scientific work, which are important to productivity. First is the *frequency of speaking with faculty about research,* which results in immediate feedback. Second is discussing and rating *aspects of position and department*, (e.g. teaching load, sense of inclusion, and recognition and rewards). This facilitates participation and status. The third feature is *characterizations of departmental climates*; perception of home unit's climate, values, and culture, which activate interest, convey standards, and stimulate or stifle performance. The last feature is the *levels of interference experienced with work and family*. Fox (2010) finds that women speak less about their research, which suggests that women are less integrated than men. Fox (2010) also finds that women rate their job with lower scores than men, which suggests that women obtain fewer benefits from the department's resources. Women also report a higher interference of work on family life, and vice versa. In alignment with Lee & Bozeman (2005), Fox (2010) argues that improving women's terms and conditions within science and academia is about changing the organizational structure and processes. Fox (2010) states that increasing the participation of women in science is about women having influence and involvement in the institutional decision making, e.g. in determining curricula, hiring decisions, resource allocation decisions and so forth.

It is not only within science that social capital is found to be important and vary between women and men. In their study of the Australian bank sector, Metz & Tharenou's (2001) find that in the early career years –and in positions of lower ranks, human capital facilitates advancement. Human capital relates to education, grades, grants, etc. However, in order for women to rise in ranks and leverage experience, social capital is the main mediator. Thus, social capital is not necessarily as important during early career years, but becomes more crucial at later stages. This suggests that women's lack of social capital prevents them from advancing, which might explain some of the gender differences observed, despite equal human capital between women and men (Metz & Tharenou, 2001). If women's scientific social networks are limited, their opportunities to participate in social circles and conduct research, publish articles, etc. are inhibited. Metz & Tharenou's (2001) findings arguably have important implications for women's advancement and more specifically the need for women to have female role models. The importance for women of having role models is also identified by Feeney & Bernal (2010), who find that having women in one's support and advice network is crucial for women and their advancement within science and academia. Because scientists exchange ideas, resources, information, and support –and reinforce each other's work in the informal networks, social capital and connections are critical (Feeney & Bernal, 2010). However, the fact that there are so few women in high rank positions in science somewhat prevents, or at least limits the opportunities for women to have female role models.

Another area, where the lack of networks and social capital also has an effect is within patenting activities. Ding et al. (2006) argue that women in science have suffered along three important dimensions: *productivity*, *recognition*, and *reward*. In their study, patents operate as a proxy for involvement in the commercial sector, and thus are similar to network participation. Patents are seen as paths to opportunities within business industries. Furthermore, patents increase chances of receiving rewards, e.g. royalty bearing license agreements with renowned companies. Out of 4227 scientists, 903 are women. Only 5,65% of the 903 women in their sample held patents, as opposed to a 13% amongst the 3324 men. Firstly, the low percentages suggest that patenting activities within science is mostly done by a concentrated number of scientists, and that it is not common practice to disclose inventions. However, Ding et al. (2006) still suggest two main reasons for why women patent less than men. Firstly, they suggest that women believe that patenting will affect their university careers negatively, wherefore they restrain from it. Secondly – and most importantly, a lack of exposure to the commercial sector means that only few women have contacts and participate in networks with the commercial sector, which causes women to patent less Furthermore, Ding et al. (2006) find that when initiating patenting, men seek advice in their large networks, whereas women rely on closer relationships. Patenting behavior therefore seems to be influenced by the scientist's network, which again highlights the importance of networks and social capital in generating opportunities for advancement.

In alignment with Ding et al. (2005), Thursby & Thursby (2005) suggest that scientists often are unwilling to disclose inventions because they fear that it will delay their research publication activity. They also find that patenting activities are initiated by a concentrated fraction of faculty and scientists. Thursby & Thursby (2005) find that women are less likely to disclose inventions and engage in patenting activities, despite the fact that women and men yield similar levels of productivity. More precisely, men's probability of disclosing inventions is 43% higher than women's, which suggest that men have wider networks and support to facilitate invention disclosure.

3.3 Developing the Hypotheses

Although the gap between the number of men and women receiving PhDs within science has narrowed, e.g. within the STEM fields, the representation of women in higher rank positions has not followed the same pace. This has led researchers and politicians to believe that women are discriminated. Additionally, it has revealed that equality is not improved simply by increasing the number of women receiving PhDs within the field. On the contrary, researchers suggest looking beyond the numbers and dive into individual and institutional factors that may affect the lower representation, and productivity, of women (e.g. Etzkowitz et al., 2003; Pollack, 2013; Fox, 2004).

Finding that women seem to face more barriers within harder sciences, which as a result puts their productivity and potential performance at risk, seem to repeat itself throughout literature. Due to academia's dominant use of productivity as a benchmark for advancement, it is crucial to understand why gender differences within productivity exist. Literature has offered several explanations behind the observed gender differences in productivity. Recently, a newer concept has been introduced, namely that of social capital. The concept has more vaguely been suggested to be part of the explanation behind gender differences within productivity. The increased reliance on co-authors and collaborations within science highlights the potential importance of social capital. Women's lower degree of social network integration prompts us to suspect that this might be part of the explanation behind gender differences within productivity. Therefore, as stated in the introduction, it is the aim of this thesis to find out:

1. *What are the reasons behind gender differences in academic productivity?*
2. *What is the role of social capital in relation to academic productivity?*

As already mentioned, we specifically investigate the research question within the field of biology in the UK. Based on the literature review, we now wish to present the hypotheses, which will be used to answer the research questions. In order to provide a fair basis for developing our hypotheses, we believe that a summary of the literature review is in order.

In the literature review on productivity and gender differences, with a few exceptions, it was found that men are more productive than women. Additionally, much of the literature has found that men receive more citations than women. Several explanations are suggested to explain productivity differences between women and men. The suggested explanations amongst other cover characteristics of family –and marital status. With regards to children's effect on productivity, the literature points in both directions. However, with a few exceptions, the majority of the literature suggests that children have a negative impact on productivity – more so for women than for men. Further, teaching -and research-orientations have been found to influence productivity patterns. More specifically, literature suggests that working for teaching-oriented departments, or simply preferring teaching activities, has a negative impact on productivity. Interestingly, literature further suggests that women have a tendency to prefer teaching to research, which in turn has an effect on productivity. The literature also suggests differing effects of individual -and institutional factors on productivity. More specifically, literature has found that within academia, men are older and have more experience than women. Further, the environment in research departments has been described as being male dominated. Additionally, the (subconsciously constructed) gender schemas and women and men's differing levels of confidence have an influence on how women fare in academia. Literature also suggests that the level of funding, the rank of position, and the years of experience points towards having a potential effect on productivity. Lastly, the literature on productivity and gender differences suggests that a degree of specialization, collaborating activities, and network integration affect productivity. Thus, literature prompts us to make the following hypotheses:

H1: Men are quantitatively more productive than women over time
H2: Men are qualitatively more productive than women over time

Given today's reliance on scientific collaborations, the findings on gender differences within network integration have important implications for men and women's ability to leverage their networks and contacts in the name of productivity. Therefore the literature review went in depth with social capital, which is highly connected to networks and collaborations, and its potential influence on academic productivity, and how these differ between men and women. The literature review on social capital, productivity and gender differences suggests that social capital facilitates productivity, and potentially also citations. It was described that the pooling of ideas and expertise facilitate performance and productivity. Given the argument that research problems today are too large for a single scientist to handle alone, it can arguably be derived that collaborations not only increase the quantity -but also the quality of productivity. The literature found differences between women and men's level -and utilization of social capital. More specifically, it was found that women have less social capital than men. Furthermore, women's networks consist of fewer bridging ties outside their local network than men. The literature suggests that the explanations behind these gender differences are to be found in the social –and organizational features of the institutions. It seems that although women and men are equally likely to posses similar human capital, e.g. by having obtained their degrees from prestigious, top-rank universities, women and men still yield differences in productivity and advancement. Thus, literature suggests that the explanations behind gender differences must lie in the social –and organizational factors. Linked to the degree of utilization, the literature indicated that members of social capital networks need to possess a certain degree of overlapping knowledge and skills, in order to understand, absorb -and utilize each other's contributions. Given that scientific research most likely is conducted in groups, and therefore is a social and organizational process, and given that performance within academic science as a consequence is tied to how well these group collaborations function, the literature's findings on women's lack of social capital are concerning, and have crucial implications for the productivity of women. Thus, it is the aim of this thesis to look into three additional hypotheses:

H3: Men have more social capital than women over time
H4: Social capital relates positively to the quantity of productivity over time
H5: Social capital relates positively to the quality of productivity over time

4. Data and Methodology

This thesis set out to investigate gender differences in academic productivity within biology in the UK, the potential explanations for this, and how social capital may relate to these gender differences. The thesis will take a positivist approach to the research question, and make use of deductive reasoning drawn from the body of literature described in the literature review, in order to ultimately answer the research question. The first part of the thesis was spent on reviewing the most relevant literature concerning gender differences within academic productivity and social capital. This gave us the foundation on which to base our hypotheses. As we use empirical tests to verify our hypotheses, data and methodology are both important for the value of the analysis. The following sections will provide in-depth explanations of the data used in this thesis along with the methodology applied to analyze the data.

4.1 Data

The thesis focuses on the scientific productivity of academic scientists within biology in the UK. Common for all scientists is that they were employed at either the University of Edinburgh (UE) or University College London (UCL) during 2001. UE and UCL are both ranked as top universities in the United Kingdom according to the World University Ranking (2012-2013). The biology departments of both universities are regarded as being top of the class, and they stand behind great inventions and scientiftic breakthroughs, such as Dolly the Sheep and the hepatitis B vaccine (The Complete University Guide, n.d.). UCL was the first university in England to admit women on the same terms as men. Further, UCL is known for hiring more women than any other university in the UK, as women make up 9% of professors and department heads, although this is still a very low percentage (Etzkowitz et al., 2003, chapter 2).

We have collected data for 302 academics; 177 from UE and 125 from UCL. The identification of the 302 academics was made possible by the Research Assessment Exercise (RAE) report in 2001. This was an exercise undertaken by British Higher Education Institutions in order to rank UK universities in terms of their research quality. The RAE report was ultimately used to allocate funding to the different universities (RAE, 2008). In connection with this exercise, all universities were required to disclose information about their academic staff. With the support from two assistant professors at Copenhagen Business School (CBS), who had access to the RAE report, we gained access to the list of academics from UE and UCL that make up our unique data sample. The list provided the academics' initials and last name.

The data collection had two major steps. First step was to identify the individuals and retrieve data on their demographic, educational and employment data, as well as society memberships and grants awarded. The second step involved extracting the individual academics' publication history from Scopus. Scopus is an online bibliographic database launched in 2004 which provides information about publications, such as journals, books and conference papers and so forth. (Scopus, 2014). From Scopus it is possible to extract the publishing year, the number of citations, and the co-authors etc. for each publication. The two steps are described in detail below. The data collection took place from Marts 2014 until the end of May 2014.

4.1.1 Step 1: Personal Data

From the RAE report, the scientists from UE and UCL were manually searched for online. To make sure the right professors were identified, we consistently ensured that they had been employed at either UE or UCL during the year of 2001. The information for all scientists was filled into an excel template.

The online research looked for the following information:

- Demographics: Year of birth, nationality, marital status, number of children
- Education: Bachelors degree, -field, -year, -and institution, Master's degree, -field, -year, -and institution, and PhD degree, -field, -year, -and institution
- Career: Listing of job positions, the respective institutions -and total years of employment
- Societal membership, grants, and entrepreneurial ventures

Once the manual, online research was conducted, we classified the academics into type 1, 2, 3, or 4. Type 1 academics indicated those academics, who were not possible to find online. Type 2 academics were found, but only minimum information was available. Type 3 academics were possible to find, with just a few limitations in the information available. Lastly, Type 4 academics were found with full information.

In order to potentially increase the data density, e-mails were sent from a CBS e-mail account to a total of 198 type 2 -and 3 academics. The e-mails requested additional information. Out of the 198 academics, 17 replied with the additional information needed. To ensure quality and verity, we only use type 3 -and 4 data for the analysis. A considerable amount of time was spent on double-checking the data -and information obtained on the type 3-and 4 academics. This resulted in a total sample size of 152 academic scientists; 83 from UE and 69 from UCL.

4.1.2 Step 2: Collecting Publication Data

Step two included extracting the publications from Scopus for each academic scientist we had hand-picked from our unique data sample. Thus, all type 3 and 4 academics were searched for in Scopus. Scopus not only provides information about the individual academics' publications, but also the university, which the given academic is affiliated with at present time, as well as the field of science he/she is working in. Using some of the information from step one made it possible for us to ensure congruence between our list of academics (from step one) and the ones found on Scopus. Once the correct academic was found on Scopus, we exported the publication information from Scopus into a CSV file, which we later converted into an excel file. We manually cleaned and edited the columns in the excel file, in order to suit the purpose of our analysis. This was done for each individual academic. The publication information for all individuals was gathered in one template. This template covers information on 13,640 publications. For each publication in the template, the publication title, the publication year, the name of the source, the number of co-authors, co-author names and finally the number of citations are presented.

4.1.3 Identifying Outliers

We identified and removed outliers by looking into each individual academic's averages of the variables presented in the following sections, i.e. publications and number of co-authors. We decided not to use citations to determine if someone was an outlier, as this would punish individuals who had written potentially good articles. Furthermore, we believe that citations are a sort of effect beyond the control of the individual scientist, whereas number of publications and co-authors may be subject to scrutiny. Furthermore, to sanity check the process, we developed graphs of the variable averages in order to visually identify potential outliers. Once we identified potential outliers, we investigated them in-depth to ensure that they were in fact outliers. We manually investigated 26 potential outliers. Out of the 26 potential outliers, 19 were not true outliers, while seven were classified as outliers, and therefore withdrawn from our data sample (two women, five men). This reduced our sample size to 145 academics in total (38 women and 107 men).

4.2 Definitions and Variables

To test our hypotheses, we need measures that capture productivity and social capital, and that can take into account gender differences. From Scopus, we will use the number of publications and the number of citations to measure productivity quantitatively and qualitatively, while we use the number of co-authors to measure social capital. In the following sections we will briefly describe the year of PhD as well as gender. Thereafter, we will describe the variables in more detail (publications, citations, co-authors). For some of the variables, we briefly discuss potentially critical implications arising from using them.

4.2.1 Definitions

- **Gender:** Gender was manually checked in step one, when searching for each individual online. Throughout this thesis, female/male and women/men are used interchangeably.
- **Scientific academics:** Throughout the thesis, the individuals comprising our data sample are interchangeably being referred to as either academics or scientific academics.
- **Year of PhD:** The PhD year is used to classify which groups an academic belongs to. The year of PhD was found in the first step of the data collection, as part of the demographic information. For 10 academics, it was not possible to find information on the year they obtained their PhD degree. Instead, we used the year of their first job as an indicator of their PhD year, as this was the case for 71% of the other academics. We also considered using year of first publication as an indicator of their PhD year, however upon investigation, we found that using the year of the first job is a more appropriate indicator.
- **Scope of time horizon:** As will be presented later, the analysis will be based on decades. In order to use full decades, we manually removed publications made before each academic's PhD year, and publications made after the year of 2009.

4.2.2 Dependent Variables - Publications and Citations

As indicated in the literature review, the most often used measure of academic productivity is the number of publications. In the literature review, it was described how Godin (2009) use both the number of articles and the number of citations to assess the output of scientific productivity.

Kelchtermans & Veugelers (2013) also use publications –and citation count to assess research productivity in their study of top performers. In this study, we use the same measures to assess the quantity –and the quality of productivity. Thus, we assess productivity from both a quantitative (publication count) –and a qualitative (citation count) angle.

The number of publications produced by a given academic is found on Scopus. Scopus indexes a larger number of journals than other databases, e.g. Web of Science, Google Scholar, and PubMed (Falagas et al., 2007). Furthermore, Scopus takes into account numerous document types, which are referred to as "publications" throughout this thesis. These document types include articles, reviews, letters, conference papers, editorials, notes, and articles in press, errata, book chapters, short surveys, and "unidentified". We extracted all published work for each individual academic in our database.

Citations are also extracted from Scopus. For each publication, Scopus gives the number of citations that the given publication has received. A limitation of Scopus is that it includes self-citations. The citation count in our data may therefore be somewhat misleading. However, due to time limitations, the scope of this thesis, and the fact that it is not within our control, we cannot account for self-citations. We therefore proceed, albeit being aware of the risk that our measure of quality may suffer from this.

4.2.3 Independent Variable - Social Capital

Several studies have tried to measure social capital. Yet its abstract definitions and intangibility of its nature makes this a difficult practice. In measuring social capital it has been widely emphasized that social capital can be either the cause or the effect of productivity (or both), which challenges the measurability even more ("Productivity Commission", 2003). Empirical studies have used a variety of measures, e.g. survey responses, membership of societies, associations, conference and/or seminar attendance, number of chair positions, and so forth. However, due to its abstract definitions, measures are often subjects to criticism ("Productivity Commission", 2003). Within academia, more recent research has made use of the number of co-authors as a measure of social capital. According to literature, the level of co-authorship can be seen as measure of network activity –and integration, and thereby social capital (e.g. Fox, 1991; Stack, 2002). Although measuring social capital based on the number of co-authors does not take into account aspects of integration in such a complex phenomenon as social networks, it is one of the best measures currently available. Therefore, this thesis uses the number of co-authors as the measure of social capital.

The data on co-authors is retrieved from Scopus. We do however wish to highlight some of the specificities concerning co-authors, which may have later implications for our use in relation to social capital.

Across scientific disciplines and journals, different requirements exist as to what actually constitutes a co-author. However, there are two versions of well-known and often used authorship criteria. The first version of criteria, presented in the World Association of Medical Editors guidelines, states that the listed authors must have made a *"(...) substantial intellectual contribution"* (Moffatt, 2011). The second version of criteria explained by the International Committee of Medical Journal Editors (ICMJE), requires that three conditions must be met for an individual to be classified as an author: *1) Substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; 2) Drafting the article or revising it critically for important intellectual content; 3) Final approval of the version to be published* (Moffatt, 2011; Vinther & Rosenberg, 2012). Thus, only when someone provides intellectual contributions should this person be counted as an author. This also means that merely providing grant money to do research is not enough to classify an individual as an author. This is true for either set of authorship standards (Moffatt, 2011). Furthermore, many guidelines require that co-authors must be able to understand, evaluate, and support the article's main points. In their study, Bhopal et al. (1997) revealed that academics and researchers at a university faculty were unaware of authorship guidelines, disagreed with them, or simply ignored them. If this is the case, the verity of co-authorship should be questioned.

Given that there are no costs for assigning many authors to a publication, authors are incentivized to put several co-authors on the author list (Holaday & Yost, 1995). Furthermore, the fact that the number of publications is the most used measure of scientific productivity, which in turn is used for professional advancement and reward, also contributes to the increased number of co-authors on publications. Scientists are incentivized to have their name on as many papers as possible, despite not having contributed much to them (Moffatt, 2011; Nguyen & Nguyen, 2006). This creates an issue of multi-authorships. Having many co-authors, and especially honorary authors, misinforms the scientific community about who is responsible for the findings in publications and thus who should also be able to defend any critique (Moffatt, 2011). However, not one standard or benchmark of how many co-authors it is acceptable to list exists (Nguyen & Nguyen, 2006). This would also harm -and potentially decrease the motivation for collaborations. Each research study has its own conditions and context, based on the nature of the field and research approach. Thus, associations can merely develop guidelines on how to list co-authors and what information must be provided about the co-author contributions, the level of accountability, and so forth.

One potential method of checking co-authors' contributions, is to look at the order in which names are listed in the publications' list of authors. However, different logics of listing authors are applied across publications. Some list authors alphabetically, others list them according to the authors' actual contributions, whilst some list according to seniority, and/or prestige.
Given these circumstances, we decided to manually investigate the most extreme numbers of co-authors in our publication data, and remove publications that listed 300+ co-authors. We believe that the level of intellectual contribution of each author is minimal in cases with 300+ co-authors. Thus, we ended up removing 29 publications from the total sample of publications.

We could arguably have been harsher in our criterion regarding the number of co-authors. However, given that we saw several articles with a large number of co-authors, cutting off publications with 300+ was a tough cut, relative to how many publications actually state over fifty and hundreds of co-authors. Lastly, it is beyond the scope of our knowledge and nature of our data to judge whether a certain number of co-authors has diminished the given publication's scientific value and integrity. A high number of co-authors may be fully legitimate for certain publications.

4.3 Analytical Base - Identifying Groups of Academics

The academic scientists in our data sample have received their PhDs during different decades. For the purpose of the analysis, we divided the academics into three groups. The academics were split up in accordance to the decade during which they received their PhD. Out of a total of 145 academic scientists, 131 were divided into one of the following three "PhD groups":

- Group 1: academics who received their PhD during the 1970s (28 academics)
- Group 2: academics who received their PhD during the 1980s (49 academics)
- Group 3: academics who received their PhD during the 1990s (54 academics)

The remaining 14 academics received their PhD either before the 1970s (12 academics) or after 1999 (2 academics). Based on a judgment call and the desire to have a minimum of statistical rigor, we decided that 12 and two individuals are too few to represent entire decades. Thus, they were withdrawn from our sample, wherefore our total sample size was reduced to 131 academics. Throughout the discourse of the thesis, the three different groups will be referred to as either the group who received their PhD during the 1970s, -1980s, -or 1990s, or as group 1, 2, or 3.

Group 1: Academics who received their PhD in the 1970s

There are 28 individuals in the group who received their PhD during the 1970s. Four of these are women (14%), while the remaining 24 are men (86%). As can be seen from the table below, the females of this group on average produce more publications per year than men. More specifically, they produce 3.17 publications per year, while the men on average produce 2.76 publications per year. The table shows that men have 46.29 citations on average, while women have 45.29. The men further have 4.08 co-authors per publication, while women have 3.8 co-authors per publication.

Group 2: Academics who received their PhD in the 1980s

The second group of academics consists of 49 academics. Out of these, 12 are women (24%) and 37 are men (76%). The women in this group again have more publications per year on average, namely 3.28, whereas the average for men is 3.18. As opposed to the previous group, the women in this group have more citations per publication than men. More specifically, women have 70.98 citations per publication, while men have 56.82 citations per publication. Men and women have approximately the same number of co-authors per publication. More precisely, women have 5.10 co-authors per publication, while men have 5.15 co-authors per publication.

Group 3: Academics who received their PhD in the 1990s

The third group received their PhD during the 1990s. This group consists of 54 academics, out of which 18 are women (33%) and 36 are men (67%). On average, the men have 2.80 publications per year. This is slightly higher than women whose average is 2.39 publications per year. The women have a slightly higher average of citation per publication than men. More precisely, women have 68.24 citations per publication, while men have 66.11 citations per publication. As in the previous group, there is only a small difference in the averages of co-authors per publication. More specifically, the women on average have 5.10 co-authors per publication, while men have 5.17 co-authors on average per publication.

Table 4.1. The table provides descriptive statistics for the average number of publications per year, average number of citations per publication, as well as the average number of co-authors per publication for each of the three PhD groups. The table reports the mean, the median, the standard deviation (Std. Dev.), the 1st percentile and the 99th percentile of the distribution of each variable. The first part of the table reports the descriptive statistics of the whole subsample, while the next two separates the subsample into male and female

		Mean	**Median**	**St. Dev**	**1st perc.**	**99th perc.**	**N**
PhD 1970s							
Total sample	Publications per year	2.82	2.15	1.86	0.42	7.03	28
	Citations per publication	46.14	37.04	37.43	8.62	187.05	28
	Co-authors per publication	4.04	3.88	1.09	2.03	7.05	28
Female sample	Publications per year	3.17	2.74	2.1	1.13	6.08	4
	Citations per publication	45.29	46.27	16.17	25.89	62.71	4
	Co-authors per publication	3.8	3.77	0.25	3.54	4.14	4
Male sample	Publications per year	2.76	1.89	1.86	0.42	7.03	24
	Citations per publication	46.29	32.17	40.14	8.62	187.05	24
	Co-authors per publication	4.08	3.9	1.18	2.03	7.05	24
PhD 1980s							
Total sample	Publications per year	3.2	2.74	1.75	0.83	7.32	49
	Citations per publication	60.29	49.31	38.76	12.55	213.64	49
	Co-authors per publication	5.14	4.93	1.63	2.16	10.26	49
Female sample	Publications per year	3.28	2.71	1.81	1.29	6.14	12
	Citations per publication	70.98	75.95	31.87	22.26	145.65	12
	Co-authors per publication	5.1	4.95	1.56	2.88	7.8	12
Male sample	Publications per year	3.18	2.74	1.76	0.83	7.32	37
	Citations per publication	56.82	46.04	40.52	12.55	213.64	37
	Co-authors per publication	5.15	4.86	1.67	2.16	10.26	37
PhD 1990s							
Total sample	Publications per year	2.66	2.12	1.76	0.43	10.44	54
	Citations per publication	66.82	49.29	49.91	9.79	261	54
	Co-authors per publication	5.14	4.72	1.55	2.5	9.25	54
Female sample	Publications per year	2.39	2.37	1.31	0.63	5.46	18
	Citations per publication	68.24	45.97	59.22	9.79	261	18
	Co-authors per publication	5.1	4.82	1.59	2.5	9.25	18
Male sample	Publications per year	2.8	2.06	1.95	0.43	10.44	36
	Citations per publication	66.11	49.58	45.47	13.36	235.88	36
	Co-authors per publication	5.17	4.72	1.55	2.87	8.65	36

4.4 Methodology

As described above, the main purpose of this thesis is to investigate gender differences within academic productivity and potential explanations behind, as well as social capital's relation to this. Throughout the analysis, women and men are divided and assessed separately, in order to assess potential gender differences. To test our hypotheses, we use t-tests and OLS regressions with robust standard errors. The t-tests are used to investigate whether the variables are significantly different between women and men. The OLS regressions with robust standard errors are used to analyze whether there is a relationship between our dependent variables, publications and citations (productivity), and co-authors (social capital). To perform the analyses of this thesis we use Stata 13, provided by Copenhagen Business School.

4.4.1 Decades analyzed

In order to be able to analyze the productivity and social capital of each PhD group over time, the analysis of each group is divided into decades. As already mentioned, we decided to cut the time horizon at 2009, in order to be able to use full decades. Dividing the analysis of each group into decades means that the group who received their PhD during the 1970s will be analyzed for the decades 1970s, 1980s, 1990s, and 2000s. The group who received their PhD during the 1980s will be anaylyzed for the decades 1980s, 1990s and 2000s. Lastly the group who recived their PhD during the 1990s will be analyzed for the decades 1990s and the 2000s.

4.4.2 T-test

Technically, t-tests are used to compare the means of two samples. In the analysis of the three groups across the decades, we will compare the means of women and men in terms of each of the three variables (publications, citations, and co-authors) within each decade. We use t-tests to test the first three hypotheses (H1, H2 and H3).

Although we analyze decades, we decided to use data from each individual year for each academic, instead of using averages for the decade. This gives us a larger number of observations to base our t-tests upon.

The formula for the t-test is given below:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

$\bar{X}_1$ = Mean of first set of values

$\bar{X}_2$ = Mean of second set of values

S_1 = Standard deviation of first set of values

S_2 = Standard deviation of second set of values

n_1 = Total number of values in first set

n_2 = Total number of values in second set.

Standard deviation is given by:

$$S = \sqrt{\frac{\sum(X - \bar{X})^2}{n - 1}}$$

X = Values given

$\bar{X}$= Mean

n = Total number of values.

4.4.3 OLS regression

In the analysis we use Ordinary Least Square regressions (OLS) with robust standard errors, which minimize the sum of squared distances between the observed and predicted observations. We are interested in the relation of social capital (co-authors) with productivity (publications and citations). Using the OLS regression helps us estimate the underlying linear relationship that can predict potential increases in productivity for a given level of social capital. We use the OLS regressions to test hypothesis 4 and 5.

For the regression analyses in the decades, we use the following equations:

$$PRO\ (quantity)_I = \alpha + \beta_1\, CIT_I + \beta_2\, COA_I + \varepsilon_I$$

$$PRO\ (quality)_I = \alpha + \beta_1\, PUBL_I + \beta_2\, COA_I + \varepsilon_I$$

CIT = Citations

COA = Co-authors

PUBL = Publications

Three major violations of assumptions exist, which can invalidate the results of an OLS regression. Thus, in order to make sure that our findings are valid, we tested our models for linearity, multicollinearity, and non-normal error terms. Firstly, we used scatterplots to make sure that the data shows a linear trend. None of the variables showed proof of violating this assumption. Secondly, we tested the variance inflation index, which was well below the "rule of thumb" of 10. Thus, our data has no problem with multicollinearity. Lastly, we used a QQ-plot to test the normality of the error terms. The plots fit the line very well, suggesting that the error terms are normally distributed. In a normal OLS regression heteroscedasticity would violate one of the critical assumptions and make inference from the results invalid. However, in our regression we use robust standard errors which mitigate any concerns about heteroscedasticity.

4.5 Validity and Reliability

Validity is concerned with the integrity of the conclusions that one draw from research (Bryman & Bell, 2006). The variables used for measuring productivity and social capital in this thesis have all been used –or recommended for use in previous research. Furthermore, using the number of publications to assess productivity is also done in real-life practice. This arguably enhances the validity of this measure. Although we previously questioned the use of citations as a measure of quality, we still believe the measure has a high degree of validity. Furthermore, we questioned using the number of co-authors due to the previously mentioned issues. However, as already touched upon, there does not exist one true measure of social capital due to its abstract nature and intangible nature. Within the scope and context of this thesis, we believe that co-authors are the best available measure of social capital, albeit recognizing its limitations.

The study of this thesis specifically focuses on academics within the field of biology in the UK. As suggested in the literature, the gender differences in productivity and partially social capital vary depending on the field of science. Furthermore, the proportion of women within the softer sciences is larger than the proportion of women in harder sciences, such as technology, mathematics and engineering. The generalizability of this study is therefore restricted to harder sciences. Given that the proportion of women in harder sciences is higher for biology than the other fields, the generalizability is restricted further to the field of biology. Furthermore, 69 out of our 131 academics received their PhD from universities that are ranked amongst top 100 worldwide. Narrowing this further, 62 of the academics in our data sample have received their PhD at universities ranked amongst the top 50 worldwide (The World University Ranking, 2012-2013, see appendix 1). Although these rankings are done several years after our academics received their PhD's, we still believe that it suggest a certain caliber of these universities. Additionally, the academics in our data sample have all worked at University of Edinburgh and/or University College London at some point during their careers. We believe that these features of the data restrict the thesis' generalizability.

Reliability questions whether the significant results would be repeated if someone else conducted the exact same research under the same conditions (Bryman & Bell, 2006). Although the data sample originally consisted of a lot of demographic information about every academic, we mostly use data that was extracted from Scopus. It is our impression that the data extracted from a well-known database like Scopus is more reliable than the data obtained via online empirical research. Collecting and gathering data online from a range of different websites implies a high risk of human error. Furthermore, the demographic information was not publicly available for all the individual academics, which limited how much use we could make of the information. Thus, the only demographic information used is gender and the year of PhD. This information is relatively simple and also stable, wherefore we do not believe that reliability is compromised. That being said, we had to base ten of the academics' missing year of PhD on the year of their first job, as explained earlier. However, we do not believe using this solution on a rather small fraction of the total data sample jeopardizes the general reliability of the data.

It can be argued that using more of the demographic information would have allowed us to assess e.g. social capital in broader -and potentially better ways. For example, we could look into memberships of academic societies. However we decided not to do so, due to discrepancies in terms of the available information for the academics, as just described.

Furthermore, we were two people collecting the data, and therefore also two people who classified the academics into types 1, -2, -3, -or 4. Given that Scopus provides consistent data for all academics, it was the demographic information -and lack of the same that determined the rather subjective classifications. Thus, the inter-observer consistency can be questioned, in the sense that different criteria may have been used for classifying the academics.

5. Results and Analysis

In this section we will analyze the productivity and social capital levels of men and women. As mentioned in the methodology section, the analysis will assess three groups. The group structure was decided in order to avoid analyzing and comparing people who received their PhD in different decades, and thus have different levels of experience. PhD decades refer to the decade in which the groups received their PhD respectively, i.e. the 1970s, 1980s or 1990s. The structure allows us to analyze and follow each group's members and their performance during the subsequent decades.

As already touched upon in the literature review, research suggests that male academics have higher productivity than females. The measure of productivity has historically mainly been based on the number of publications or articles, whereas quality has been assessed using measures such as citations, journal source, impact, and so forth. Additionally, the literature review suggests that men are more integrated in networks and therefore have higher levels of social capital. Based on the extensive literature review, we presented our five hypotheses. In order to test our hypotheses we make use of different statistical tests. In the first three hypotheses, our aim is to compare women and men across variables. Therefore we conduct t-tests to answer the first three hypothesis, which are:

H1: Men are quantitatively more productive than women over time

H2: Men are qualitatively more productive than women over time

H3: Men have higher social capital than women over time

In addition to the three hypotheses, we developed two additional hypotheses. The aim of the two hypotheses is to assess the relation between social capital and productivity. In order to do so, we conduct two different OLS regressions using robust standard errors. The first regression uses *publications* as the dependent variable, whereas the second uses *citations* as the dependent variable. Given that we still want to compare women and men with regards to the relation between social capital and productivity, we run the two OLS regressions for both women and men separately for each of the three groups, in each of their active decades. Therefore we test hypotheses 4 and 5 for women and men separately using OLS regressions. These hypotheses are:

H4: Social capital relates positively to the quantity of productivity over time

H5: Social capital relates positively to the quality of productivity over time

In the following sections, we will present the empirical results in three steps: Firstly, the univariate results (t-tests) and the multivariate results (OLS regressions) for the group who received their PhD during the 1970s is presented. Secondly, the univariate –and the multivariate results are presented for the group who received their PhD in the 1980s, and thirdly the uinvariate –and multivariate results for the group who received their PhD during the 1990s is presented. Following the presentations of the statistical results, we will state whether our hypotheses are supported or rejected. Lastly, we will present what the results suggest on a more practical level making use of the previously described literature.

5.1 Results of group 1

5.1.1 Univariate

Table 5.1 shows the results from the t-tests by reporting the means, the medians and the p-values of all the variables for women and men. In order to capture the development of the female and male scientists within the group we have conducted a t-test for each active decade, i.e. the 1970s, the 1980s, the 1990s and the 2000s, and for each variable (publications, citations, co-authors). This approach is applied throughout the analysis of the three groups.

Publications: Analyzing the publications of the group who received their PhD during the 1970s, shows that the means of both women and men increase for each decade. Women's means are higher than men's in all decades. For example, in the first decade (1970s) women have a mean of 1.06, while the mean for men is 0.76. In the last decade (2000s), the means for women and men have increased to 4.50 and 3.87 respectively. There are no significant differences between women and men across the four decades

Citations: In the first two decades (1970s and 1980s), women have higher means than men. In the 1990s however, men have a higher mean than women. In the 2000s, women again have a higher mean than men. There are no significant differences between women and men over time. Again, the means increase overall for each decade for both women and men.

Co-authors: Analyzing the differences between women and men in terms of co-authors, shows the same pattern as for citations. During the 1970s, women have a higher mean than men with 3.12 and

2.00 respectively. Women also have higher means in the 1980s, however, only slightly. In the subsequent decade (1990s), men have a higher mean than women, while in the 2000s women again have a slightly higher mean than men. The mean differences are fairly small for all decades, and none of them yield any significance.

Table 5.1 - T-test statistics for academics who received their PhD in the 1970s. The table reports the mean, median, t-stat, and p-value.

PhD in 1970s		***Female*** *n = 4* Mean (Median)	***Male*** *n = 24* Mean (Median)	t-stat [p-value]
1970s	Publications	1.06	0.76	0.937
		(1.0)	(0.0)	[0.175]
	Citations	17.29	14.16	0.232
		(6.0)	(0.0)	[0.408]
	Co-authors	3.12	2.00	1.236
		(2.0)	(0.0)	[0.109]
1980s	Publications	2.26	1.91	0.937
		(2.0)	(2.0)	[0.175]
	Citations	78.40	72.01	0.220
		(32.5)	(13.0)	[0.413]
	Co-authors	6.00	5.93	0.054
		(4.0)	(3.0)	[0.479]
1990s	Publications	4.00	3.47	0.977
		(4.0)	(2.0)	[0.165]
	Citations	204.53	252.00	- 0.600
		(82.5)	(86.0)	[0.275]
	Co-authors	12.50	14.13	-0.621
		(9.5)	(9.0)	[0.268]
2000s	Publications	4.50	3.87	1.040
		(3.0)	(3.0)	[0.150]
	Citations	250.83	232.29	0.273
		(90.5)	(88.0)	[0.393]
	Co-authors	21.88	20.51	0.351
		(14.0)	(12.0)	[0.363]

*** p<0.01, ** p<0.05, * p<0.1

The findings from the t-tests suggest that there are no significant differences between women and men across the decades in any of the variables. Hypothesis 1 is rejected for the group who received their PhD during the 1970s. Men are not quantitatively more productive than women over time, measured by the number of publications. On the contrary, women have higher quantitative productivity in all four decades, although not significant. In terms of quality, measured by the number of citations, we find no significance. Actually, men have lower means than women in three out of the four decades. We subsequently find no evidence for confirming hypothesis 2, and hence reject it. In other words, men do not have higher qualitative productivity than women over time.

In terms of social capital, measured by the number of co-authors, women actually show higher means in three out of the four decades. Therefore we reject hypothesis 3. Men do not have higher social capital than women.

5.1.2 Multivariate

In this section we will present the results from the OLS regressions using robust standard errors, in order to assess the potential relationship between social capital and productivity. As already explained, we run the regressions within each decade, in order to capture the development over time. For each decade we firstly run regressions with publications as the dependent variable, and secondly with citations as dependent variable. This approach is applied throughout the analysis of the three groups. In order to compare women and men, we run the regressions for women and men separately in each decade. When linking the regressions results to the hypotheses, the main focus will be the variable that represents social capital, namely co-authors. This means that the relationship between publications and citations, and vice versa, will not be further elaborated, as we believe the relationship is strongly reinforcing and beyond the main topic of this paper.

Publications as dependent variable: Table 5.2 reports the results from the regressions with publications as dependent variable. In the first decade (1970s) citations show no significant relationship with publications. In the following decade (the 1980s), citations significantly relate to publications on a 1% significance level for both women and men. In the third decade (1990s), women's citations are not significantly related to publications, whereas men's citations are significantly related to publications on a 5% level. In the last decade (the 2000s), the relationship between citations and publications is significant on a 1% level for both women and men.

Interestingly, table 5.2 shows that co-authors and publications relate positively to each other across all decades for both women and men. In the first decade (1970s), the significance level for women is 10%, while for men it is 1%. Women's coefficient is lower than men's coefficient. In the next decade (1980s), co-authors and publications relate to each other at a significance level of 1% for both groups. The difference between women and men's coefficients in this decade is minimum. The third decade (1990s) shows significance on a 1% level between co-authors and publications for both women and men. This time, women's coefficient is slightly higher than men's. The last decade (2000s) also shows significance on a 1% level for both women and men. The coefficients for both women and men in this decade are lower than their respective coefficients in the two previous decades. The regressions have high explanatory power with R-squared statistics above 0.8, with one exemption for women during the 1970s.

The results across the decades for the women and men who received their PhD during the 1970s suggest that social capital, measured by the number of co-authors, is significantly related to the quantity of productivity. Therefore hypothesis 4 is supported for both women and men. Social capital relates positively to quantitative productivity over time.

Table 5.2 - Robust OLS regression for the academics who received their PhD in the 1970s. Publications as dependent variable.

PhD in 197(	***1970s***		***1980s***		***1990s***		***2000s***	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Publications	Female	Male	Female	Male	Female	Male	Female	Male
Citations	0.004	0.002	0.007***	0.001***	0.002	0.000**	0.003***	0.002***
	(0.004)	(0.002)	(0.002)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Co-authors	0.132*	0.321***	0.211***	0.228***	0.227***	0.171***	0.158***	0.116***
	(0.067)	(0.029)	(0.038)	(0.011)	(0.034)	(0.013)	(0.022)	(0.009)
Constant	0.578**	0.099***	0.411***	0.482***	0.787***	0.940***	0.289	1.107***
	(0.257)	(0.030)	(0.143)	(0.056)	(0.277)	(0.136)	(0.264)	(0.115)
Observations	17	131	40	240	40	240	40	235
R-squared	0.2683	0.8627	0.8262	0.8273	0.8111	0.8146	0.9264	0.8111

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Citations as dependent variable: Table 5.3 reports the results from the OLS regressions with robust standard errors, with citations as the dependent variable. In the first decade (1970s), there is no significant relationship between publications and citations for either women or men. However, in the next decade (1980s), publications relate significantly to citations on a 1% significance level for both women and men. Here, women have a slightly higher coefficient than men. In the 1990s, there is a significant relation between publications and citations on a 10% level for women, while there is no significance for men. During the last decade (2000s), publications relate significantly to citations on a 5% significance level for women, and on a 1% significance level for men. Women's coefficient here is lower than men's.

Co-authors do not relate significantly to citations for either women or men in the first two decades (1970s and 1980s). However, women's coefficients in both decades are negative, whereas men's coefficients are positive and negative. In the 1990s, there is no significance for women regarding co-authors relation to citations. However for men, the significance level is of 1%. Interestingly, in the last decade (2000s) the table shows a negative relationship between co-authors and citations for both women and men, although with no significance.

The regressions have relatively high explanatory power with R-squared statistics above 0.4 for most of the models. The only exemptions are in the 1970s where R-squared for women and men are 0.0234 and 0.1958 respectively. Additionally, men's R-squared is 0.1471 in the 1980s.

The regression on citations suggests that co-authors, i.e. social capital, have little relation with citations, i.e. the quality of productivity for both women and men. However, in the 1990s there is a significant relationship for men between social capital and the quality of productivity. The same pattern is not observed for women. Therefore, hypothesis 5 is rejected for women. For men, we believe it is a stretch to partially support hypothesis 5 based on significance in only one out of four decades. Therefore, we are prompted to reject hypothesis 5 for men, knowing that this is a matter of opinion.

Table 5.3 - Robust OLS regression for the academics who received their PhD in the 1970s. Citations as dependent variable.

PhD in 197(	***1970s***		***1980s***		***1990s***		***2000s***	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Citations	Female	Male	Female	Male	Female	Male	Female	Male
Publications	5.521	16.972	51.106***	44.121***	35.690*	33.353	66.906**	81.480***
	(5.679)	(11.647)	(14.143)	(16.092)	(19.962)	(20.710)	(32.221)	(17.032)
Co-authors	-1.075	0.849	-2.850	-2.176	8.421	13.820***	-0.169	-1.941
	(1.597)	(4.573)	(4.439)	(3.758)	(7.322)	(4.387)	(5.870)	(2.197)
Constant	14.799	-0.493	-18.212	3.740	-43.500**	-59.028*	-46.544	-43.090
	(10.709)	(1.104)	(14.790)	(8.408)	(17.520)	(33.943)	(32.904)	(26.417)
Observations	17	131	40	240	40	240	40	235
R-squared	0.0234	0.1958	0.6052	0.1471	0.5186	0.4319	0.7255	0.3456

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2 Results of group 2

5.2.1 Univariate

Publications: Table 5.4 shows the results from the t-tests for the group who received their PhD during the 1980s. In the 1980s, men on average have more publications than women, although not significant. In the second decade (1990s) men have significantly more publications than women on a 10% level. However, during the last decade (2000s), women have more publications than men on a 5% significance level.

Citations: During the 1980s women on average have fewer citations than men, however, the difference is not significant. In the following two decades (1990s and the 2000s) women on the other hand have more citations than men. However, the differences are not significant for either decade.

Table 5.4 - T-test statistics for academics who received their PhD in the 1980s. The table reports the mean, median, t-stat, and p-value.

PhD in 1980s		***Female*** *n = 12*	***Male*** *n = 37*	
		Mean (Median)	Mean (Median)	t-stat [p-value]
1980s	Publications	1.19 (0.5)	1.34 (1.0)	-0.484 [0.314]
	Citations	42.05 (0.0)	53.25 (2.0)	-0.406 [0.343]
	Co-authors	4.17 (1.0)	4.66 (2.0)	-0.376 [0.354]
1990s	Publications	2.68 (2.0)	3.12 (3.0)	-1.570 [0.059*]
	Citations	280.99 (87.5)	224.08 (87.5)	1.127 [0.130]
	Co-authors	10.72 (6.0)	14.46 (10.0)	-2.356 [0.009***]
2000s	Publications	4.97 (4.0)	4.23 (3.0)	1.985 [0.024**]
	Citations	307.68 (175.5)	255.41 (111.0)	1.133 [0.129]
	Co-authors	29.10 (20.0)	25.53 (18.0)	1.231 [0.110]

*** p<0.01, ** p<0.05, * p<0.1

Co-authors: During the first decade (1980s) women have fewer co-authors than men, but with no significance. In the 1990s, women have fewer co-authors than men on 1% significance level. During the last decade (2000s), women have more co-authors than men. However, the difference is not significant.

The results from the t-test suggest that men are quantitatively more productive than women during the 1980s, significantly more during 1990s on a 10% level, but not during the 2000s. According to the logic applied in the previous group, we could potentially reject hypothesis 1, due to the fact that we only find significance in one out of three decades. However, although not significant, men are also more productive on average in the 1980s. Therefore we decided that hypothesis 1 is partially supported. Men are quantitatively more productive than women for some of the time. In terms of the quality of productivity, measured by the number of citations, men have higher quality during the 1980s, but not in the next two decades (1990s and 2000s). Although men have higher quality in the 1980s, the result is not significant. Therefore, hypothesis 2 is rejected. Men are not qualitatively more productive than women over time.

Lastly, the results suggest that men have more social capital during the 1980s and significantly more during the 1990s on a 1% significance level. However, during the 2000s women have more social capital, although not significant. Again, we could potentially reject hypothesis 3, based on the logic from the previous group. However, although we only find significance in the 1990s, men still have more social capital in the 1980s, albeit not significant. We decided that hypothesis 3 is partially supported. Men have more social capital than women for some of the time.

5.2.2 Multivariate

Publications as dependent variable: Table 5.5 shows the results from the robust OLS regressions with publications as dependent variable. During the first decade (1980s), citations have no relation with publications for either women or men. However, in the 1990s, citations relate positively to publications for men at a significance level of 1%, whilst there is no significant relation for women. In the 2000s, there is a positive relation between citations and publications on a 1% significance level for both women and men.

The regression shows a positive relation between co-authors and publications on significance levels of 1% in every decade for both women and men. However, the coefficients differ for women and men across the decades. In the 1980s and 1990s, women's coefficients are higher than men's. In the 2000s, men's coefficient is higher than women's. The regressions have relatively high explanatory power with R-squared statistics above 0.6.

The results suggest that social capital is significantly related to quantitative productivity for the group who received their PhD during the 1980s. Therefore, we find strong support for hypothesis 4 for both women and men; social capital relates positively to the quantity of productivity.

Table 5.5 - Robust OLS regression for the academics who received their PhD in the 1980s. Publications as dependent variable.

PhD in 1980s	***1980s***		***1990s***		***2000s***	
	(1)	(2)	(1)	(2)	(1)	(2)
Publications	Female	Male	Female	Male	Female	Male
Citations	0.001	0.000	0.000	0.001***	0.003***	0.001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Co-authors	0.248***	0.211***	0.206***	0.117***	0.073***	0.089***
	(0.018)	(0.011)	(0.020)	(0.013)	(0.018)	(0.010)
Constant	0.125**	0.332***	0.452***	1.157***	1.997***	1.612***
	(0.052)	(0.046)	(0.112)	(0.116)	(0.356)	(0.202)
Observations	42	208	120	370	118	357
R-squared	0.9346	0.8718	0.7670	0.6982	0.6576	0.6179

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Citations as dependent variable: Table 5.6 shows how the variables relate to the number of citations. During the 1980s, publications positively relate to citations for both women and men. However the relationships are not significant. During the 1990s, publications positively relates to citations for women, but with no significance. For men on the other hand, publications relate to citations on a 1% significance level. In the 2000s, the relationship between publications and citations becomes significant for both women and men at a 1% level.

Regarding co-authors, women in the 1980s have a negative relation between co-authors and citations, while for men the relationship is positive. However, none of the two relations are significant. In the next decade (1990s), we find a positive relation between co-authors and citations for women, however not significant. For men however, we find a significantly positive relation on a 1% level. In the 2000s women again have a positive relation between co-authors and citations, but with no significance. However, we find a positive relation between co-authors and citations for men on a 5% significance level.

The regressions have moderately explanatory power with R-squared statistics being above 0.1 and at the highest around 0.4.

The results suggest that there is no significant relationship between women's social capital and the quality of their productivity. Thus, despite the positive coefficients, we reject hypothesis 5 for women. However, for men, social capital shows a significant relation with the quality of the productivity in the 1990s and the 2000s. Therefore hypothesis 5 is partially supported for men, suggesting that social capital relates positively to the quality of productivity some of the time.

Table 5.6 - Robust OLS regression for the academics who received their PhD in the 1980s. Citations as dependent variable.

PhD in 1980s	***1980s***		***1990s***		***2000s***	
	(1)	(2)	(1)	(2)	(1)	(2)
Citations	Female	Male	Female	Male	Female	Male
Publications	21.169	23.172	7.823	57.068***	69.361***	39.110***
	(45.226)	(14.883)	(46.844)	(17.783)	(20.494)	(13.961)
Co-authors	-1.606	7.348	18.618	8.840***	1.178	4.137**
	(11.717)	(5.553)	(11.810)	(3.299)	(1.439)	(1.592)
Constant	23.540**	-12.105	60.543	-81.888***	-71.051	-15.633
	(8.824)	(9.039)	(42.289)	(28.626)	(51.844)	(30.173)
Observations	42	208	120	370	118	357
R-squared	0.1098	0.3296	0.1462	0.4396	0.4044	0.2835

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.3 Results of group 3

5.3.1 Univariate

Publications: Table 5.7 shows the t-tests conducted for the group who received their PhD during the 1990s. For the first decade (1990s), men on average are more productive in terms of publications than women. However, this difference is not significant. In the subsequent decade (2000s) men have more publications than women on a 1% significance level.

Citations: Men have more citations than women during both the 1990s and the 2000s. However, the differences in both decades are not significant.

Co-authors: In the 1990s men have slightly more co-authors than women, however, the difference is not significant. In the following decade (2000s) men have more co-authors than women on a 1% significance level.

The findings from the t-tests suggest that men who receive their PhD in the 1990s are quantitatively more productive than the women during both the 1990s and the 2000s. However, the finding is only significant in the 2000s, wherefore hypothesis 1 is only partially supported. Men are only quantitatively more productive than women some of the time. Regarding the quality of productivity, i.e. citations, the t-tests yield no significant differences, although men obtain more citations on average than women. However, due to the lack of significance we reject hypothesis 2. We do not find that men are qualitatively more productive than women over time. Lastly, as the t-tests only find that men have significantly more co-authors than women in the 2000s, hypothesis 3 is only partially supported. Men have more social capital than women some of the time.

Table 5.7 - T-test statistics for academics who received their PhD in the 1990s. The table reports the mean, median, t-stat, and p-value.

PhD in 1990s		***Female*** *n = 18*	***Male*** *n = 36*	
		Mean (Median)	Mean (Median)	t-stat [p-value]
1990s	Publications	1.68	1.90	-1.067
		(1.0)	(1.0)	[0.143]
	Citations	163.64	209.40	-1.003
		(44.5)	(64.5)	[0.158]
	Co-authors	7.35	8.72	-1.226
		(4.0)	(6.0)	[0.110]
2000s	Publications	2.75	3.47	-2.488
		(2.0)	(3.0)	[0.007***]
	Citations	169.68	210.55	-1.009
		(63.0)	(79.5)	[0.157]
	Co-authors	14.00	19.61	-2.382
		(10.0)	(12.0)	[0.009***]

*** p<0.01, ** p<0.05, * p<0.1

5.3.2 Multivariate

Publications as dependent variable: Table 5.8 shows the OLS regressions with robust standard errors conducted for the group who received their PhD during the 1990s. The table reports that during the 1990s, citations relates positively to publications on a 1% significance level for men. Meanwhile, there is no significant relationship between citations and publications for women in this decade. During the subsequent decade (the 2000s), citations have little relation with publications for both women and men, and there is no significance.

In the 1990s co-authors positively relate to publications on a 1% significance level for both women and men. In the next decade (2000s), co-authors and publications also relate to each other on a 1% significance level for both women and men. The regressions have relatively high explanatory power with R-squared statistics above 0.6

The results from the regression suggest that social capital positively relates to quantitative productivity for both women and men across all decades. Therefore, hypothesis 4 is fully supported. Social capital relates positively to the quantitative productivity over time.

Table 5.8 - Robust OLS regression for the academics who received their PhD in the 1990s. Publications as dependent variable.

PhD in 1990s	**1990s**		**2000s**	
	(1)	(2)	(1)	(2)
Publications	Female	Male	Female	Male
Citations	0.001	0.001***	0.001	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
Co-authors	0.130***	0.140***	0.136***	0.096***
	(0.031)	(0.012)	(0.020)	(0.008)
Constant	0.618***	0.472***	0.723***	1.510***
	(0.167)	(0.069)	(0.185)	(0.213)
Observations	120	250	175	352
R-squared	0.6242	0.7676	0.6926	0.7437

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Citations as dependent variable: Table 5.9 shows the regression using citations as the dependent variable. In the 1990s, we find a positive relation between publications and citations for women on a 1% significance level. For men, the significance level is 5%. The following decade (2000s) shows a positive relationship between publications and citations for women on a 1% significance level. For men the relation is also positive, however without any significance.

During the 1990s, the regression shows no significant relationship between co-authors and citations for either women or men. However, the relationship is positive for women, while it is negative for men. In the 2000s, there is a positively significant relation between co-authors and citations for women on a 10% level. For men, we find a positive relation, but it is not significant.

The regressions have moderate explanatory power with R-squared statistics above 0.1.

The results suggest that for women, social capital, measured by the number of co-authors only has a significant relation with the quality of productivity, i.e. citations, during the 2000s. Therefore hypothesis 5 is only partially supported for women. For men, social capital shows no relation with the quality of productivity, wherefore hypothesis 5 is rejected for men.

Table 5.9 - Robust OLS regression for the academics who received their PhD in the 1990s. Citations as dependent variable.

PhD in 1990s	***1990s***		***2000s***	
	(1)	(2)	(1)	(2)
Citations	Female	Male	Female	Male
Publications	59.965***	162.299**	31.546***	19.120
	(21.252)	(66.527)	(11.651)	(43.016)
Co-authors	0.353	-7.940	4.627*	8.569
	(4.584)	(10.608)	(2.634)	(7.624)
Constant	60.110*	-29.729	18.198	-23.874
	(33.128	(26.228)	(17.638)	(32.413)
Observations	120	250	175	352
R-squared	0.1005	0.2947	0.6926	0.4101

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. Extension of Analysis

As we have gone through the statistical results of the three groups, we now wish to summarize these results, bring forth the main findings, and link these to literature. It is our ambition to find explanations in literature for why we see the results that we do. Although some of our results are not significant, they may still be of interest. Therefore, we also attempt to explain the results with no significance, in order to get a better understanding of the different groups and their development over time. To enhance the understanding and consensus, we complement each group's section with graphs of the three variables' means. Although we use these graphs, our goal is to now move beyond the exact statistical results. We strive to do so, by only referring to the specific hypotheses, and by focusing on more qualitative inputs. Table 5.10 summarizes the findings from the statistical analysis.

Table 5.10 - Summary of hypotheses

Hypotheses	**PhD in 1970s**		**PhD in 1980s**		**PhD in 1990s**	
	Female	Male	Female	Male	Female	Male
H1	Rejected		Partially supported		Partially supported	
H2	Rejected		Rejected		Rejected	
H3	Rejected		Partially supported		Partially supported	
H4	Supported	Supported	Supported	Supported	Supported	Supported
H5	Rejected	Rejected	Rejected	Partially supported	Partially supported	Rejected

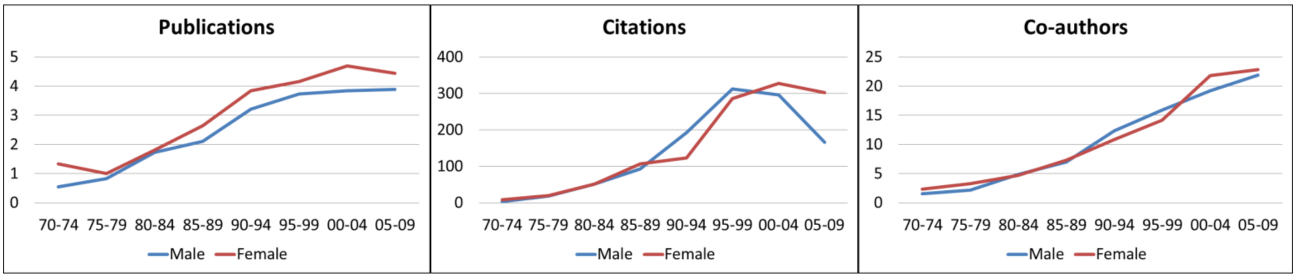
H1: Men are quantitively more productive than women over time
H2: Men are qualitatively more productive than women over time
H3: Men have more social capital than women over time
H4: Social capital relates positively to the quantity of productivity over time
H5: Social capital relates positively to the quality of productivity over time

6.1 Extended Analysis for Group 1

For the group who received their PhD during the 1970s, we cannot say that men are quantitatively more productive than women over time. Further, we cannot say that men are qualitatively more productive than women over time. Lastly, we cannot say that the men in this group have more social capital than women over time. Therefore hypotheses 1, 2, and 3 were rejected. The results suggested a significant positive relationship between social capital and quantitative productivity over time for both women and men. Thus, hypothesis 4 was supported for both women and men. The relationship between social capital and qualitative productivity was less clear. Thus, hypothesis 5 was rejected for both women and men.

Below is a graphic illustration of the means of women and men who received their PhD in the 1970s. The first graph shows the means of publications, the next graph shows the means of citations, while the last graph shows the means of co-authors.

Graph 5.1 - Graphic illustration of the variables and their developments for the academics who received their PhD in the 1970s



In this group, 14% are women, whilst 86% are men. Although we did not find a lot of significance in the t-tests, the differences observed are still interesting to dive into. As touched upon in the literature review, studies find that men are more productive than women. However, our findings do not suggest that men produce significantly more than women. In fact, looking at the means, we find that women who received their PhD during the 1970s are quantitatively more productive than men across all decades, although not significantly.

It may be reassuring to find that the analysis of this group failed to identify significant gender differences, and assume inequality no longer exists. However we do not believe this is the case. Although our data does not allow us to come up with the exact reasons for women's unexpectedly high performance, literature allows us to make qualitative guesses. The women interviewed by Etzkowits et al. (2003, chapter 6) explain that women ahead of them, i.e. most likely also back in the 1970s, had an even tougher time in academic science than is the case today. Consequently, they were forced to be very aggressive in order to fare ahead in a very male dominated environment. Presumably, the four women in our group of academics who received their PhD during the 1970s have survived several barriers in order to reach the high levels of productivity – both quantitatively and qualitatively. Thus, it may be that the women in this group can be classified as "superstars"; women, who despite tremendous barriers fought for their careers, where other women chose to withdraw.

The "superstars'" levels of ambition have potentially made them deselect having children (and family) in order to focus on –and fight for their careers. As the literature review suggested, having children influences productivity and performance negatively. Due to the limitations of our data, we do not know whether the four women have children. However, back in the day (but also nowadays) women were expected to take on caring and nurturing roles. Within science, the mutual exclusion of career and family has been evident, and the women who are in relationships or pregnant are often taken less serious (Etzkowitz et al., 2003, chapter 6). Thus, deciding not to have children could potentially be a reason for the women's high productivity and performance, as suggested by Creamer (1999). Breaking with society's expectations and choosing not to have children, potentially suggests a strong determination and an extreme will to fight for their academic careers.
Additionally, Vange et al. (2005) suggest that women who work in research-oriented departments deselect children in order to focus on research productivity. In research-oriented departments, it is expected that research is the center of attention. Thus it may be that the women in this group have mostly worked in heavily research-oriented departments, wherefore they have potentially deselected having children, in order to produce and perform. Furthermore, it was normal, and potentially still is normal, to expect scientific academics to devote their entire lives to their work; this basically made up the definition of a true scientists, i.e. that one devoted all time to work and research (Etzkowitz et al., 2003, chapter 2).

Another reason why the women of this group perform well may be that they have been subject to gender schemas and the mathilda effect (Etzokowitz et al., 2003, chapter 6; Larivière et al., 2011; Valian, 2004). This would potentially mean that the performance of the women in this group has been undervalued by default. Thus, they have had to work harder and produce more to attain the same level of recognition as their male colleagues, who have received recognition for less effort (Kamerasde, 2007).

In terms of the quality of productivity, literature tends to suggest that men have higher qualitative productivity than women, as measured by citations, patents and so forth. However, we do not find this to be the case for this group. A few other studies have found that women produce publications of higher quality than men. It has been suggested that the reason for this is because women spend more time on analyzing, interpreting, and confirming research findings, which ensures a higher quality. Thus, it has been suggested that women obtain more citations, because they produce publications of higher quality than men (Mauléon & Bordons, 2006; Larivière et al., 2011; Kamerasde, 2007; Valian, 2004). We may argue that this is also the case for the women in this group, as the results show they have higher averages of citations than men for most of the decades. However, contrary to the women in the studies of Mauléon & Bordons (2006), Larivière et al. (2011), Kamerasde (2007), and Valian (2004) the women in our sample do not produce less, while having a high quality. Instead, the women in this group manage to obtain many citations along with a high number of publications. This may support the idea that these women are superstars.

In terms of social capital, the results showed a significant positive relationship between social capital and quantitative productivity throughout the decades. This relationship is also supported by literature, as shown in the literature review. Literature also suggests that women are less networked than men, and therefore have less social capital (Fox, 2010; Gupta et al., 2005; Etzkowitz et al., 2003, chapter 12). However, this does not seem to be the case for the women in this group. With the exception of the 1990s, women in this group on average have slightly more co-authors than men. Although not significant, this finding contradicts most literature on social capital and the gender differences within. An explanation behind this finding is rather hard to find. As already suggested, it might be a result of these women being superstars. However, it may also be that co-authors were not as important during the 1970s and 1980s, wherefore the small differences we do see, are merely random. Although women have more co-authors for most of the time, the regression coefficients showed that men might be better at utilizing their network to increase quantitative productivity in the first two decades (1970s and 1980s), while the women might be better at doing so in the last two decades (1990s and 2000s). This may suggest that men in the beginning are better integrated in their networks, and therefore better linked to their co-authors. However, this might be a far-fetched guess, taking into account the limitations of our data.

An interesting finding from the regression on citations and its relation to co-authors, although not significant, is that women's coefficients are negative in almost all decades (except for the 1990s). This might suggest that additional co-authors do not increase the quality of women's publications. Instead, the quality may decrease at the addition of co-authors. However, the results need to be taken on with caution and this suggestion therefore might also be far-fetched.

Based on the above, we recommend future research to take on the task of investigating the different degrees of women and men's ability to utilize their networks to increase their productivity – both quantitative and qualitative.

Summing up, it is our belief that that the women in this group are superstars who have performed extremely well throughout their careers. We believe this is the case despite of the results during the 1990s, during which men yield higher means of publications, citations, and co-authors. A word of caution however, is that the statistical analysis for this groups is based on a very small sample of women. As is the case with much statistical analysis, we therefore cannot infer with certainty.

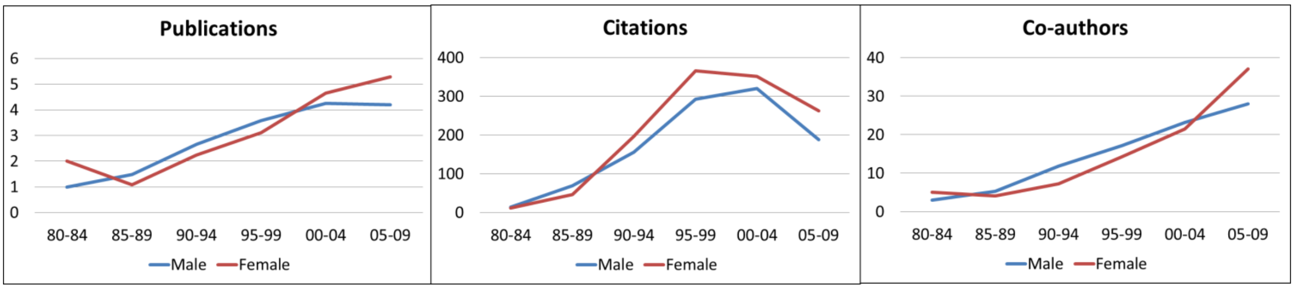
6.2 Extended Analysis for Group 2

For the group who received their PhD during the 1980s, men are quantitatively more productive than women, but only during the 1990s. Therefore hypothesis 1 was partially supported. Hypothesis 2 was rejected, as we do not find men to be qualitatively more productive than women across the decades. Lastly, hypothesis 3 was partially supported, as we find that men have more social capital, however only significantly so in the 1990s.

The multivariate analysis showed that social capital relates positively to the quantity of productivity over time for both women and men. Therefore hypothesis 4 was supported. For women, hypothesis 5 was rejected, as we do not find that social capital related positively to the quality of productivity. However for men, we find a significant relationship between social capital and quality in the 1990s and 2000s, wherefore hypothesis 5 was partially supported.

The graphs below illustrate the means of publications, citations and co-authors for women and men over time.

Graph 5.2 - Graphic illustration of the variables and their developments for the academics who received their PhD in the 1980s



In the group who received their PhD during the 1980s, women make up 24% of the group, while men make up 76%. Thus, we see an increase in the percentage of women compared to the previous group, which only consisted of 14% women. As opposed to the previous group, men are more productive than women in the first two decades after receiving their PhD. This finding can have several reasons.

It may be that the women produce less due to the fact that they start building families. Given that the UK's educational trajectory is fairly fixed and that our academics are fairly ambitious, the academics in may be approximately 25-27 years old when they receive their PhD. Assuming that most women start families at ages 30-35, pregnancy and caring-responsibilities might take away women's focus on research during parts of the first two decades. Most literature suggests that having children effects productivity negatively (Etzkowitz et al., 2003, chapter 6, 9, 10; Misra et al., 2012; Hunter & Leahey, 2010). Even in research-oriented institutions, Misra et al. (2012) find that women devote more time to parenting instead of conducting research. Thus, although the women in this group, like the women in the other groups, come from renowned universities where research is presumably in focus, and although they may acknowledge that research is alpha omega to productivity, the women may still deprioritize research activities in favor of children -and family responsibilities. Further, it is found in literature that when women compromise due to family obligations, they cut in their research -instead of teaching responsibilities. One explanation behind this is that women tend to care about the people they teach and seek to minimize how much people are affected by their absence (Misra et al., 2012).

Further, some literature suggests that women tend to prefer teaching activities, which include social contact and caring, whereas men tend to prefer researching activities, which include data and analysis (Winslow, 2010; Kessler et al., 2013). It has also been suggested that women, due to various forms of discrimination and gender schemas, tend to be hired into less research-intensive departments –and/or lower-rank positions. It is arguably these places where resources are most limited (Hesli & Lee, 2011; Vange et al., 2005; Ceci & Williams, 2010). Men on the contrary take up higher rank positions where resources are in abundance. Resources facilitate productivity (D'amico & Vermigli, 2011; Mauléon & Bordons, 2006; Ramsden, 1994; Black & Holden, 2006). Whether sincere preference, deliberate choices, or due to institutional (discriminating) factors, teaching activities arguably takes away time from research, and therefore reduces productivity. Due to the nature of our data, we cannot say whether the women (and men) in our sample are productive qua other activities, such as mentoring, teaching, or advising students. However, it may be that the women engage in such activities wherefore we see a lower quantitative productivity for women than the men.

Social capital might also explain the women's lower productivity. Literature suggests that women are less integrated in networks and therefore have less social capital than men. According to literature this affects productivity negatively. During the 1980s and 1990s, we found that women are quantitatively less productive than men. During the same decades, women also have fewer co-authors. If the number of co-authors is an indication of social capital (Stack, 2002; Etzkowitz et al., 2003, chapter 12), women's lower level of social capital may be related to their lower productivity. The low levels of social capital may be due to institutional factors and the male dominated culture in universities. Further, a consequence of having children is that women's time to build bridges and improve their social capital is reduced.

Interestingly, although women produce less (quantitatively) in the 1980s and 1990s, the regressions showed that their coefficients between co-authors and publications are higher than men's. This means that for each additional co-author, women increase their productivity more than men. Given their lower productivity, this might suggest that women in general depend more on their co-authors. Literature suggests that women specialize less in specific research areas than men, which affects their productivity negatively. Specializing less forces women to depend more on co-authors to increase productivity, because they need to cover a wider range of research areas than they can on their own. Men on the other hand specialize more, and are therefore less dependent (Leahey 2006, Etzkowitz et al. 2003). Thus it may be that the women in our sample specialize less than men, wherefore they are more dependent on their co-authors.

Literature supports the claim that social capital is important and needed to perform and advance in (academic) science (Etzokowitz et al., 2003, chapter 12; Metz & Tharenou, 2001; Thursby & Thursby, 2005; Ding et al., 2005). It is worth noting that women increase their number of co-authors during the 2000s. When this happens, their co-author-publications coefficients (and citations) decrease. This may suggest that only a certain number of co-authors actually add value to the quantitative -and qualitative productivity. This is to say that it may not always be value-adding to have several co-authors.

Interestingly, although men are quantitatively more productive in the 1990s, women are qualitatively more productive, measured by citations (although not significant). A reason for this may be found in literature. As touched upon in the previous group, some literature suggests that women are more focused on ensuring the quality of their publications (Barbezat, 2006; Valian, 2004). Thus they spend more time ensuring that their research findings are correct, get feedback -and confirmation. Furthermore women tend to combine several research findings in one article, whereas men tend to spread their research findings across several articles (Etzkowitz et al., 2003, chapter 2). This may be why we see women have quantitatively fewer publications, but a higher qualitative productivity.

During the third decade (2000s), we see that the women produce quantitatively and qualitatively more than men. This may be because their potential children have grown old enough to take care of themselves. This arguably leaves time for the mothers to focus on their research and careers again.

To sum up, the group of academics who received their PhD in the 1980s shows a different trend than the previous group. The group consists of an increased percentage of women. However, the men seem to be performing better than women, at least in the first two decades of their careers. It is our belief that family obligations partially may explain the findings, as family inevitably takes time -and focus away from research. Lastly, we believe that women are disadvantaged in terms of building networks and raising social capital, due to e.g. institutional factors, old traditions or alike.

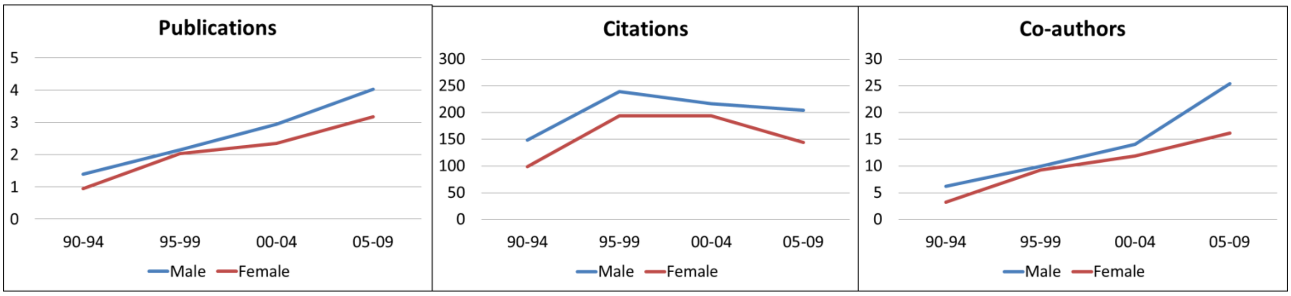
6.3 Extended Analysis for Group 3

For the group who received their PhD in the 1990s, hypothesis 1 was only partially supported, as men are quantitatively more productive, however only significantly in one of the decades (2000s). Men are not qualitatively more productive then women over time, wherefore hypothesis 2 was rejected. Lastly, men only have significantly more social capital in one decade (2000s), wherefore hypothesis 3 was only partially supported.

The multivariate analysis showed that social capital is significantly related to quantitative productivity, wherefore hypothesis 4 was fully supported for both women and men. The relationship between social capital and qualitative productivity is less clear. For women we only find a significant positive relation in one decade (2000s), wherefore hypothesis 5 was partially supported. For men, hypothesis 5 was rejected, as there was no significant relation to be found.

Below are graphs that illustrate the averages of publications, citations, and co-authors for women and men over time.

Graph 5.3 - Graphic illustration of the variables and their developments for the academics who received their PhD in the 1990s



The first interesting factor to note with regards to the group who received their PhD during the 1990s is the increased percentage of women. Women now make up 33% of the group. This might reflect a growing presence of women in science. Within harder sciences, biology is the only field that has managed to integrate women better than others, such as engineering, and mathematics (Etzkowitz et al., 2003, chapter 1). Although it is an increase, the percentage is arguably still low when talking about equality.

The desire to have a personal life besides working has increased in society, not only for women but also for men (Etzkowitz et al., 2003, chapter 6). It seems reasonable to assume that this might be the case for the people in this group. If this is indeed the case, the lower productivity and lower number of co-authors for women might be explained by a deliberate choice and preference towards building families, as was also the case with the previous group.

Furthermore, institutional changes have taken place within the academic settings, followed by an increased focus on women in science, and many initiatives to promote gender equality (e.g. the SWAN charter and WISE). These factors may have facilitated more women into science.

For the same reason, it may be that more "less well-performing" women are present in this group. Less well-performing women would arguably produce fewer publications. Further, the quality of their work might be lower. Some literature suggests that the focus on increasing the representation of women has led to what is known as a diluting effect or reverse discrimination. For example, Vange et al. (2005) suggest that too much fear and focus on the discussions on gender (in)equality in some places has led to the lowering of requirements for women. Hereby the quality of women's work may be reduced, because they are allowed to put in less effort. Given that the 1990s presumably should offer better conditions in terms of equality, than was the case earlier, it may be that the women in this group have been subject to less scrutiny in terms of the quality of their work, which may have resulted in fewer citations.

However, despite many initiatives to promote women in science, there is no guarantee that conditions have improved for women. Thus, an alternative explanation for the lower performance of the women in this group may simply be that the institutional conditions have not improved for women. Much literature has highlighted the mistake of merely focusing on the quantitative number of women present in science, as this has led to a tendency to highlight this number, without much attention to whether these women are doing well and are satisfied. A numerical focus does not in itself improve women's conditions (Etzkowitz et al., 2003; chapter 6). Thus for this group, it may be that the numerical presence of women has increased, but the institutional factors that ought to facilitate women's fare and advancements have not, as evident from the women's lower quantitative and qualitative productivity as compared to the men.

As noted, the women in this group have a lower level of social capital than men on average. This might be explained by the fact that increasing social capital requires attending conferences, seminars, traveling and so forth, in order to expand networks. This is hard for women to do if they have to take care of their families. This may explain the lower level of social capital found for women when compared to men. Further, Etzkowitz et al. (2003, chapter 8), suggests that supervisors/mentors are more inclined to invite male PhD students to conferences and seminars, wherefore men have an advantage in terms of building social capital from the onset of their careers. We found that social capital relates significantly to the quantity of productivity. Furthermore, the means show that the women and men in this group initiative their careers with much higher numbers of co-authors compared to the two previous groups. This might imply that network integration and social capital has become a common and emphasized part of education and early-career years.

The graphs above show that women and men develop similarly, albeit women having lower levels of publications, citations, and co-authors. This may suggest that the lower levels we see for women are caused by e.g. family responsibilities or a lack of institutions to adapt –and improve women's conditions within science as just touched upon. However, the finding may also be due to the limited nature of our data for the group who received their PhD in the 1990s. For example, if we had had data for an additional decade, we might have seen a different picture. Potentially, adding an additional decade could have given us the same pattern as seen in the previous group analyzed; men performed better in the first two decades, where after women performed better in the third decade, once their kids have grown old enough to take care of themselves.

Summing up, we believe it is fair to say that we see some of the same trends as in the previous group. Consequently, the reasons explaining the developments in the group are more or less the same as to the previous group.

7. Discussion

This thesis set out to investigate gender differences within academic productivity and the role of social capital. This was done by empirically investigating the productivity and levels of social capital for three groups of academics. The group structure was based on the given decade in which the academics received their PhD. In this way, potential time/historical effects could be captured, and the effects of experience taken into account.

In the following sections we will discuss the findings from our analysis. The topics discussed will revolve around productivity and social capital. The aim of the discussion is not to explicitly compare the three groups analyzed, but rather to discuss our analysis in general. However, the three groups and their inherent differences will be discussed in more detail where it is deemed interesting and necessary. The discussion will also take place in light of the available literature.

7.1 Productivity

In general, our findings relating to productivity and gender differences oppose a majority of the literature. When we embarked upon this journey, we expected to find that the men in our sample were more productive than the women. However, as shown in our analysis, this is not the case per se. We found no repeating pattern across the groups or decades of men producing more publications or obtaining more citations than women. On the contrary, the findings on productivity, be it quantitative -or qualitative, were rather sporadic, with women and men on average following each other fairly close across the variables. It might be tempting to conclude that gender differences within productivity no longer exist. However, the lack of larger gender differences instead prompts us to highlight characteristics of our data sample, which we believe may have resulted in our findings not necessarily supporting the literature. Investigating the universities from which the academics in our sample obtained their PhD's, we found that our data sample consists of people from rather prestigious universities (see appendix 1 for an overview of the universities). These universities have historically ranked fairly high on university world rankings and have good reputations. We can only assume that coming from a prestigious university with well-established practices and resources may have had a facilitating effect in terms of capability, experience, productivity, and potentially also social capital. Furthermore, a requirement when collecting the data was that the people had worked at either University of Edinburgh or University College

London in 2001. These universities are amongst the top of the class when it comes to biology. Such prestigious universities inevitably attract interest, and spill over certain credibility to the people having obtained degrees –or been hired there. This arguably facilitates an easier fare for the academics, who at some point have been associated with such universities. We suspect that these characteristics of our data might be a reason why we have the findings we do. We cannot generalize or conclude, based on our findings, that there are no differences between women and men within the field of biology in the UK. We believe more research is needed, in order to understand the potential role of the university rank and reputation, and its characteristics in relation to gender differences.

7.2 Social capital

In our analysis of social capital, our findings seem to support literature in terms of social capital's relation to productivity (mainly quantitative productivity). Although we identified positive relations between social capital and productivity, this does not mean they are causal. Based on the literature review, we expected to find stark gender differences in the levels of social capital. However, our findings did not replicate available literature on social capital in terms of gender differences. Again, we cannot say exactly why this is the case. It may be that being associated with prestigious universities attracts co-authors, wherefore we see fairly high –and almost equal levels of social capital between women and men.

The regressions in our analysis confirmed what literature had already suggested; namely that social capital and productivity (in our case quantitative productivity) relates significantly. Although our hypotheses suggested so, we had not expected to find such a strong relationship between co-authors and publications for the group who received their PhD during the 1970s. We were under the impression that social capital and the increasing trend of co-authoring was not yet in focus during the 1970s, or the 1980s for that matter. Based on literature and pre-research, we were under the impression that the concepts of co-authors -and social capital both were fairly new. However, this is not what our analysis suggests. This "discrepancy" between literature and our findings may be due to limitations in our data and/or the way we chose to assess social capital. Furthermore, there is the question of the hen and the egg. We cannot say whether productivity increases social capital, or whether social capital increases productivity. Potential reinforcing effects are not captured, which arguably would make a valuable contribution to research. In addition, we have no insight into how scientists find their co-authors. Thus, we do not know whether they came from social capital, networks, a student, or rather a reference from a colleague or alike.

Across the decades within each of the three groups, our findings showed an increasing trend of social capital, i.e. the average number of co-authors increased for each decade (see table 6.1). It may be that the number of co-authors increases along with experience. The trend might also point towards an increase in the importance of co-authors in general, given the social nature of newer scientific (academic) group work.

As can also be seen from table 6.1, not only do the numbers of co-authors increase for each group within each decade. When we look at all three groups and their respective initial levels of social capital, i.e. the number of co-authors during the decade they receive their PhD, we see an interesting and to some extend expected trend. The initial level of social capital increases gradually when comparing the group who received their PhD in the 1970s with the groups receiving their PhDs in the 1980s and in the 2000s. This might suggest an increasing –and earlier occurring importance of social capital during education -and career. It may imply that the pure nature of publishing has moved even further away from the lone scientist. It might also suggest that universities and/or students themselves have become better at getting integrated in networks, and that they start building their social capital foundation earlier on, e.g. during their educational years.

Table 6.1 – Increase in the number of co-authors. The table reports the mean of co-authors for each of the three groups in each decade

Co-authors	1970s	1980s	1990s	2000s
Group 1: PhD in the 1970s				
Female	3.12	6.00	12.50	21,88
Male	2.00	5.93	14.13	20.51
Group 2: Phd in the 1980s				
Female		4.17	10.72	29.10
Male		4.66	14.46	25.53
Group 3: PhD in the 1990s				
Female			7.35	14.00
Male			8.72	19.61

Interestingly, along with the increase in co-authors, the interdependence between co-authors and publications becomes smaller as seen from the regressions. This make us speculate that there might be a limit to how much more value additional co-authors can add. However, we recognize that more advanced statistics are needed for this to be proven. Despite this, we suspect that at some point there may be too many chefs in the kitchen. Thus, we are prompted to question the use of co-authors as a valid measure of social capital, as we do not know who conducts the actual research. Although we removed outliers, there are still publications with extremely high number of co-authors assigned in the data sample we used. As touched upon in the methodology, the increase in number of authors has been attributed to more doubtful aspects of co-authorships, such as honorary authorship, ghostwriting, and gift authorship. Despite prohibition, honorary authorship is in itself omnipresent, and a significant problem. In 2008, honorary authorship accounted for 26% of the listed authors in leading medical journals (Moffatt, 2011). Some authors have been found to actively engage in fraud and taking credit for papers that they have not contributed to. Individuals of high-status, grant providers and alike may also demand to be put as co-authors, in return for e.g. providing a grant, lending laboratory equipment for the research and so forth. In more extreme cases, merely having suggested –or referred to e.g. a graphic design agency to handle the visuals have led to that person being listed as a co-author (Moffatt, 2011). It seems evident, that we cannot deny the potential inflation that is taking place when co-authors are assigned to publications.

In the literature review it was amongst other argued that disciplinary diversity affects productivity positively (e.g. Stvilia et al., 2010; Reagan & Zuckerman, 2001). This suggests that larger groups of co-authors imply a larger pool of knowledge and experience. Assuming that the whole is greater than the sum of its parts, more co-authors should arguably result in higher quality. However, the results in our analysis barely yield any correlations between co-authors and citations. This might relate to the above discussion, and again question the assumed benefits derived from co-authoring. However, it may also illuminate a potential topic for future research. Research could strive to shed light on the exact qualitative contributions of co-authors. This could potentially help in understanding whether, –and in that case when, there is a limit to how much value additional co-authors add.

Lastly, our findings did not support literature suggesting that women have less social capital than men. On the contrary, we found that the women and men have close to equal levels of social capital.

Furthermore, the literature review suggested that women are more social by nature, and tend to prefer activities such as teaching and mentoring, which involves social interactions. It seems puzzling that literature suggests that women have less social capital, but are more social by nature in their work activity preferences. Although based solely on literature and therefore not related to our specific findings, this potentially suggests that there barriers that do not allow women to fully utilize their passion for social interaction for their own professional gain. We may be tempted to blame the male-dominated terms and conditions within science. It might be that women's version of what utilizing social skills is, are perceived too soft in the eye of men. However, we would rather recommend future research to look into the social aspects of the challenges that women meet when building up their social capital networks. We believe benefits can be derived from understanding why women according to literature seem socially cut off, although they are said to possess social skills and preferences by nature.

As evident from the above, our findings differ from those suggested by literature. We have come up with several suggestions as to why this might be. Additionally, we have identified areas that we believe needs further research, as this thesis can of course only cover so much. Although our findings do not support literature, they still have implications for women within science. We will dive into this in the next section.

8. Implications

The importance of equality in science is omnipresent. With more women (and more people in general), the size and diversity of the knowledge pool increases. This arguably facilitates breakthrough research and innovations. Thus, not only should it be in the interest of women, but also of universities to obtain equality. Equality also creates goodwill and positive reputations, which in return attract talented students and faculty (Valian, 2004). By not challenging inequality, universities break the norm of universalism, i.e. that scientific careers should be open to all who have the talent, regardless of their personality, gender, race and so forth (Etzkowitz et al., 2003, chapter 2).

In the first part of the implications, we will raise topics that stem from the analysis and discussion of this thesis. Literature is used to support the analysis-based implications. The last part of the implications mainly draws on available literature. We believe that the limitations of our data constrain the number of implications that can be derived. Therefore, we bring in qualitative implications.

Our first implication might be more a concern than an actual implication. This concern revolves around the low proportion of women across all three groups. Although the percentages may be higher than in other fields within STEM (Etzkowitz et al., 2003, chapter 1), we believe that talents and potentials are left untapped. The women and men in our sample perform almost equally well. The women arguably prove that there is no good reason for not seeing more women in science. We believe that the lower representation of women emphasizes the importance of institutional factors in explaining the in-literature much discussed gender differences. That is, gender differences cannot be explained by a lack of skills, ability or passion, but more so by factors beyond the control of the individual women. Within more humanistic fields of science, women and men have for long been equally represented, and the women's talent arguably better utilized (Stack, 2002; Fox, 2004; D'Amico et al., 2011). Therefore we believe that there is a lot more potential within the harder, male-dominated fields of science to improve -and promote the advancement of women. It is time to break up with gender schemas -and attribution biases. This is done by getting people on board and changing the general mindset within academic science.

Although some might question the usefulness of role models, we believe they are important. Role models are beneficial to maintain and ensure women's motivation and participation in science. However, the presence of women in science alone is not enough. A role model must be engaged, committed, and proactively pursue actions that help, motivate and support the people who need it. We believe that the women in our sample are potential role models, who should take on their share in promoting equality. Part of their tasks as role models could include reflecting on their own experiences, and hereby identifying and acknowledging barriers which women in science may stumble upon. Role models should reach out. Furthermore, they could reflect on their own behavior as successful women in science; what did they do to come so far? Did they attempt to act like the dominant male-scientists, or did they stay true to themselves? Were they subject to gender schemas and e.g. per default undervalue the work of women? Or do they act according to gender schemas themselves? To sum up, the women should evaluate –and take actions based on their own experiences and knowledge of how things are done in institutions. The women, especially the ones who received their PhD during the 1970s, may have been through harsh barriers, know the rules of the game, and may therefore also know how to change it.

As mentioned in the discussion, we suspect that scholarly productivity arguably covers a wider range of tasks than tangible outputs in the form of publications. We believe that institutions and faculty should strive to evaluate academic performance in more innovative ways, and potentially reduce the dominant focus on publications. New methods of evaluating should take into account the variety of work that academics do besides publishing articles, such as unpublished articles, presentations, mentoring, advising, and so forth. Furthermore, faculty who facilitate collaboration and are proactive in nurturing the social and informal environment at the institutions could also be evaluated or rather awarded for their efforts. Thus, parts of the opportunity for equality may lie in addressing evaluation practices and policies. It can be considered whether better way of measuring qualitative productivity should be found.

Along with more appropriate performance measures, there may be a need for transparency. For instance, literature suggested that female scientists at universities do not know what is required from them in order to advance (e.g. Fox & Colatrella, 2006). Thus, information and guidelines must be shared with all faculty, so all are equally well informed about procedures, requirements, deadlines, etc. Along with an increased transparency, opportunities become clear to faculty, which in turn may facilitate equality.

We believe that the strong relation found between social capital and productivity arguably emphasizes an importance of being socially skilled. We believe that academics should strive to be social, interactive and communicative, both intra-departmental, inter-departmental, across institutions and across country borders. This would facilitate collegial relations. However, proximity is also important, as it may easier facilitate the development of trust between colleagues. Proximate relationships are useful for the instant needs at hand, such as feedback, emotional support and the like. In short, a good collegial environment can support women in science, by e.g. recognizing and reinforcing their work and by providing instant feedback and advice.

The importance of social networks should be highlighted by teachers, mentors, and supervisors during students' educational years. We believe that institutions could launch certain programs that ensure students' introduction to networks, and conference –and seminar attendance for both female –and male students. This way students can start building a base for later collaborations when their careers have kicked-off. Furthermore, both students and faculty must learn to nurture and maintain their networks, in order to derive the potential benefits. In short, it is important to ensure successful integration into informal social networks.

Besides questioning formal procedures, institutions also need to ensure equal opportunities for all faculties, by focusing on the climate and culture. They could do so by implementing monthly, weekly or even daily social activities, e.g. luncheons, common coffee gatherings, small clubs for faculties with interests in e.g. sports, arts or other hobbies. Furthermore, team building events, and/or opportunity for influence through workshops or alike may facilitate knowledge sharing and social interactions. Hereby institutions can increase awareness of cultural/climate issues and the opportunity to openly address these. Introducing such activities in a milieu not used to this may be received with rejection and confusion. Therefore, institutions could consider awarding the people or departments that support -and come up with constructive ideas on how to solve the issues being addressed.

The traditional expectations as to what truly makes a scientist needs to be questioned and adapted to the increasing desire to have a life besides work. Additionally, the research –and teaching ratio may need reevaluation, and made more flexible. From literature, it seems that work-life balance is a struggle for women in science. This issue should be approached. The European Parliament's Gender Equity Committees have for example suggested adjusting the length of workdays, hiring temporary substitutes during various forms of leaves, restructuring teaching responsibilities and ensuring childcare support (Ceci & Williams, 2010). Furthermore, private institutions have proven successful in considering opportunities for childcare solutions (Etzkowitz et al., 2003, chapter 10). This way, the institutions may become better at taking care of faculty's needs, which amongst other could support the advancement of women in science.

Along with the growing desire to have a life besides work, the values of men and women have been become very similar (Valian, 2004). Although, men might be better at prioritizing work over private life, one cannot deny the increasing omnipresence of softer values. Attitudes as well as the legal frameworks regarding equality arguably have -and still are changing, (Dannell & Hjerm, 2012). This means that more men will express the same needs as women. In order to maintain faculty and their commitments and enthusiasm, it is therefore crucial that these needs are taken care of, and not just assumed away as being typical for women, or as depreciating the quality of work. This development may make science more adaptable to women, and therefore facilitate their advancement.

To sum up the implications, the concern of the low percentage of women was emphasized. This led to the recommendation that the women from our data sample, should take on the task as role models. Additionally, the measure of academic productivity was questioned, a long with a recommendation to increase transparency of the requirements needed to advance. Subsequently, the importance of social skills and network integrations was covered along with its implications. Recommendations for improving the climate and culture between colleagues were provided, as well as the suggestion to implement more flexible work opportunities during leaves. Lastly, a general awareness and adjustment to the changing and converging needs of women and men was recommended.

9. Limitations

Like most papers, this thesis has its limitations. Limitations may have an influence on the validity of our findings, wherefore we find it important to highlight them.

First of all, we would like to acknowledge the limitation arising from using a data sample of such a small size as we do. Due to external obstacles and time limitations, it was not possible for us to expand our database. It is our advice that future research operates with much larger data samples in order to obtain stronger results and reliability.

As touched upon in the methodology, we decided to use data extracted from Scopus, due to a limited and less reliable amount of demographic data. Using Scopus is more reliable than what could be obtained from various websites. However, during the process of writing the thesis, we discovered that Scopus has its own malfunctions and therefore limitations.

Despite Scopus being a known and useful database, we stumbled upon several discrepancies during the writing of our thesis. Scopus' definition of publications covers a variety of "products", as already mentioned in the methodology. When exploring the publications, and their respective citations, in depth, some numbers of citations were strikingly high. After further investigation we discovered that some of the publications actually are computer software programs. Assuming that it was not feasible to develop software programs during the 1970s (or even 1980s) as people were not as computer savvy as today, we are prompted to question whether our comparison of the individuals' productivity is fair. In hindsight, we might have found a more reasonable comparison base had we only selected actual journal publications, and disregarded all other forms of Scopus' publication types. On the other hand, this could also result in a disaccrediting of individuals who potentially have focused on other forms of publications than journal articles. Each individual scientist is to some extend unique; unique in their strength of research, capabilities, and passion, which potentially makes them focus on different topics and means of publishing. This arguably makes it challenging to ensure a fair base for comparing productivity.

Although Scopus' definition of publications covers a wide array of publication activities, our approach to productivity is still limited in the sense that it is restricted to completely tangible outputs. However, being a scientist, professor, or lecturer also means conducting intangible activities such as teaching, advising, mentoring students and so forth. In essence, this means that productivity arguably is more than just the written word. Future research should look into finding a measure of productivity that better captures the range of activities that academics perform.

Further, we believe that the measure of quality based on citations also might be questioned. It can be discussed whether citations fully reflect quality, given that a publication may also be cited when it is criticized. Further, it may be argued that investigating the impact of the journals in which articles are published better assesses quality. Arguably, the correct measure of quality depends on the used measure of productivity. Thus, as touched upon earlier, if productivity includes teaching and mentoring, the quality is better assessed by surveys or direct feedback. In relation to how we use publications to measure productivity, citations seem like a fair measure of quality however.

Another example of a discrepancy was found when looking at co-authors. In the name of co-authoring, some of the individuals in our sample had written articles together. Thus, the given article was observed twice; one for each author. However, in a few of these instances, the number of registered co-authors and citations were different. For others of the reoccurring articles, the co-author and citation counts were congruent, and therefore correct. We were puzzled when we realized that Scopus would allocate different numbers of citations and co-authors for the same publication. Therefore, we believe it may have affected our data, which prompts us to question the quality of the data. A further example of a discrepancy in Scopus was discovered when we went back to Scopus later in our thesis process, to sanity check some of the publications of our individuals. For several individuals, the number of their publications had suddenly either increased or decreased. The changes were not caused by additional publications in the year of writing the thesis alone. This would only be natural. On the contrary, the discrepancies also related to the individual's early years of publishing where more publications could suddenly be added. Due to time limitations, we did not extract the data from Scopus all over again, although this arguably would have heightened the quality of our data. Thus, we acknowledge the discrepancies and have only managed to correct parts of the discrepancies we believe there to be.

Our statistical methods also bring forth limitations. With regards to the OLS regressions we used the count of co-authors, citations and publications from the same decade, derived from the same publications. It may be argued that we should have set up the data for our regressions differently, so it would take into account lagged effects. For example, we could have used co-authors from one decade *(t)* and relate it to productivity from another *(t+1)*. However, we are under the belief that it hardly takes a decade for social capital to have an effect on productivity. Thus, we have decided to use the variables from within the same decade, although we recognize the limitation of this approach.

Another statistical limitation relates to the regressions, as we have not incorporated fixed effects. We do subsequently not control for unobserved fixed effects relating to individual authors. "Superstars" are thus pooled together with less productive researchers within decades, which could potentially bias the results. We recommend that future research accounts for the potential bias and control for fixed effects in order to get a more clear picture of how productivity, social capital and gender play together.

A further limitation of our data relates to the individual groups, and the decades they initiate and end their careers. In each of the groups, a person may enter at any point during the first decade. That is, individuals may have received their PhD during any year of the first decade. This means that within each groups' first decade, we do not necessarily have observations of e.g. publication activity for the full 10 years of the decade, as some became active only by the end of the decade they are accounted for. As mentioned in the methodology, this is amongst other the reason why we have few observations for women who received their PhD in the 1970s; in reality they did not become active before the late 1970s.

The topic of this thesis was our first encounter with the fields of harder science, academia, and the policies and much-debated gender differences within. Therefore our literature search focused on academia and gender differences in general, without taking into account the differences inherent in today's universities. In hindsight one may argue that we should have focused our literature search on academics within more prestigious and high-ranked universities, as our data mainly consists of individuals from such universities. The individuals in our data have all been at University of Edinburgh or University College London at some point in their career. However, the amount of literature focusing specifically on gender differences and productivity within high-ranked universities is rather limited. We may presume that the issues of gender differences might be different depending on the quality, resources, and prestige of the universities. This might be why our analysis does not seem to support majority of the literature. No matter the reason, we believe that this is a research area that could be much more focused in its approach in the future.

As already touched upon in the literature review and the discussion, the assessment of social capital in this thesis may be put under scrutiny. However, it is difficult to find one measure of social capital. Under the circumstances and the topic of the thesis, using co-authors as a measure of social capital was deemed most appropriate. However, we do find the more qualitative approaches useful for capturing the density of ties within social capital networks. For example, social network analysis (SNA) tools can be used to map communication patterns and the density of these, based on surveys, interviews and program algorithms (Ehrlich, 2005). This would arguably capture the more social aspect of networks, which we do not capture with the mere count of co-authors. However, in overall it is our belief that research has a long way to go in relation to social capital, as it seems that social capital has many faces and dimensions.

The information covered by our data is also rather limited, due to the focus on Scopus. For example, grants are extremely important within research. Thus we believe that having data that includes resources and grants would be useful for the analysis of gender differences and women's fare in science. Furthermore, including more demographic data would be an interesting add-on to the statistical results, as this arguably would facilitate better understandings and explanations behind the findings.

Another limitation of our thesis, or rather an interesting area of future research, may be the collaborating strategies that scientific researchers undertake. Although our results indicates strong correlations between social capital and productivity, it would be interesting to understand ways in which collaborations take place, and the different collaboration strategies that may be available. It would be interesting to get a better insight to the actual social activities of collaborating and co-authoring, so we know when it actually can be defined as social capital, and not pure professional networks.

10. Conclusion

This thesis set out to answer the research questions: *What are the reasons behind gender differences within academic productivity*? Further, *what is the role of social capital in relation to academic productivity?*

After a thorough literature review, we learned that gender differences between male –and female academics have been frequently found. More specifically, the majority of the literature found that male academics are more productive than female academics. Amongst the suggested explanations brought forth were family –and child caring obligations, teaching –and research preferences, individual –and institutional factors, funding, gender schemas, position rank and years of experience, specialization, and lastly collaborations and the use of co-authors. The latter linked directly to the more recent topic and theory of social capital. From the literature review on social capital, it was suggested that social capital facilitates productivity. Furthermore, literature has found that men are better integrated into networks than women are, and therefore have higher levels of social capital. This could partially explain why men are more productive than women. Based on the literature review, we developed five hypotheses, which were we used to answer our research questions.

In order to test the hypotheses, we hand-collected and manually verified data covering demographics, education, and career information, as well as publications for 131 individual academics, which were used in our analyses. Based on a group structure that split the academics into three different groups depending on the decade they received their PhD's, we conducted univariate and multivariate analysis for each group.

Our analysis did not reveal the same degree of gender differences as proposed by existing literature. We found that within the field of biology in the UK, the picture of gender differences is not as clear-cut as suggested by literature. Due to the explanatory limitations of our data, we extended the analysis by drawing on existing literature in order to explain our findings.

The women from group 1, i.e. those who received their PhD in the 1970s, showed an interesting trend of higher productivity than men, although not significant. It was suggested that these women are “superstars”, who have overcome various barriers in order to receive their PhD in the first place, and therefore perform so well. Additionally, we speculated whether these women decided not to have children, in order to focus on their academic careers.

The women from group 2 produced less than men during the 1980s and 1990s, but less in the 2000s. Drawing upon literature it was suggested that potential family -and child caring responsibilities resulted in the women’s lower productivity. We suggested that the women’s later increase in productivity is potentially due to the fact that their family obligations have diminished, e.g. the children have grown old enough to take care of themselves.

The women in the last group, who received their PhD in the 1990s, produced less than men. Thus, we saw similar trends as group 2 and therefore suggested the same explanations. However, the percentage of women in this group has increased to 33% from 24% in group 2, and 14% in group 1. We discussed whether the increase of women in science has resulted in a higher number of “less well-performing” women, whose work might not be of as high quality as the women before them. Additionally, we discussed whether the focus on equality and letting more women into science might have resulted in reverse discrimination, i.e. the lowering of requirements for women. Furthermore, we believe that the increased number of women could be explained by institutional factors. During the 1990s, society at large focused more on equality. Therefore several initiatives were launched to promote women in science.

Answering our research question, we suggested various reasons for why there are gender differences in terms of productivity. Although we are aware of the limitations from the data and the numerous qualitative explanations we bring forth instead, we believe that we highlighted some of the most applicable reasons for why gender differences exist for academics within biology in the UK.

In addition to investigating gender differences in academic productivity, we also set out to investigate the role of social capital in relation to this. We found positive -and significant relations between social capital and the quantitative productivity across all decades for all three groups. We therefore believe that social capital plays an important role in relation to academic productivity.

Furthermore we found that the level of social capital within each group increase over time. Looking across the groups, we also found that the initial levels of social capital were higher the later the group had received their PhD’s. We believe and also suggested that the use –and importance of social capital has increased over time. This should also be seen in light of the nature of research and publishing, which has transitioned from being something for the lonely scientist, into something that is conducted in groups. Based on the positively significant correlations, the increase of social capital across decades and groups, and the nature of how research is conducted nowadays, we firmly believe that social capital plays an important role in terms of quantitative productivity.

When testing the relationship between social capital and qualitative productivity (citations), the picture was less clear to us. Only few of the decades within the groups revealed a significant relationship between social capital and qualitative productivity. Interestingly, although not significant, we found that the regression coefficients tended to decrease when the number of co-authors increased. Therefore we believe that there is a limit to how much value additional social capital, in the form of co-authors, can add.

Following the analysis, we discussed the use of our measures, i.e. publications, citations and co-authors, as we identified several issues arising from using these. For example, we discussed whether publications truly capture academic productivity, considering the many activities academics actually perform. Furthermore, we discussed whether the risk of self-citations could be an issue. Lastly, the thesis touched upon issues in relation to why and how co-authors are assigned to publications. The seemingly inflation in the assignment of co-authors prompted us to question the use of co-authors as a measure of social capital. We therefore suggested future research to investigate appropriate measures of social capital in the context of academic publishing activities.

In extension of questioning our measure of productivity, we suggested that the assessment of academic productivity should take into account a broader range of activities, such as teaching, advising students, mentoring and so forth. This is especially important given the dominant use of publication productivity as a benchmark for promotions and general advancement.

We were concerned about the low proportion of women in our database, as we believe they illustrate that we still have a long way to go in order to reach equality within academic science. We believe that the role of social capital and its relation to productivity has important implications for female academics and their advancement in science. We suggested that talented and well-faring female academics should proactively take on the responsibility of role models. Furthermore, the importance of social capital and network integration should be emphasized and facilitated early during the educational years. It seems that the culture and climate of institutions need to be shook up. Therefore, it was suggested that awards and recognitions are put in place for academics who contributes to the improvement of the social climate and culture. Lastly, the importance of institutions to support a balanced work-life culture was highlighted.

We recognize that our data and findings suffer from several limitations. We highlighted limitations of the analysis' definition of productivity. In relation to this, our assessment of social capital was put under scrutiny. Co-authors as a measure of social capital is arguably not an all-embracing way of assessing social capital, as it does not capture the underlying network dynamics. Furthermore, several weaknesses from relying on data from Scopus were identified. We also believe that the small size of our data sample causes limitations to the analysis' findings overall. Additionally, the degree of enlightenment from our statistical methods could be questioned.

All in all the findings in this thesis did not find clear cut explanations for why there are gender differences within academic productivity. However, we believe to have found the most applicable reasons for why the women in our data perform differently from men. Furthermore, the results confirmed the importance of social capital in relation to academic productivity, which would suggest that the scope of social capital within harder academic sciences is worth researching more into depth.

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12. Appendix

Appendix 1: Over view of the ranking of universities from which the individual academics received their PhD's

University	World Rank	Number of academics receiving a PhD
Harvard University	2	2
University of Oxford	2	10
Stanford University	4	2
MIT	5	1
University of Cambridge	7	11
University of California, Berkely	8	1
Imperial College London	10	4
Swiss Federal Institute of Technology (ETH) in Zurich	14	1
Johns Hopkins University School of Medicine	15	1
University College London	21	6
University of Texas at Austin	27	1
University of Wisconsin-Madison	30	1
King's College London	38	3
University of Edinburgh	39	18
Top 50:		***62***
Kyoto University	52	1
Heidelberg University	68	3
University of Sydney	72	1
University of Durham	80	1
University of Ghent	85	1
Top 100:		***69***
Birkbeck, University of London	102	3
University of London	102	6
Sheffield University	112	1
University of Glasgow	117	3
Sussex University	121	2
University of Sussex	121	1
Indiana University of Bloomington	132	1
University of Leeds	139	2
University of Warwick	141	2
University of Exeter	148	1
University of Birmingham	153	2
University of Bern	157	1
University of Nottingham	157	4
University of Leicester	161	2
University of Liverpool	169	2
Vienna University	170	1
University of East Anglia	174	1
University of Aberdeen	188	1
University of Reading	194	2
University of Dundee	196	1
University of Newcastle	198	3
Cardiff University	201	1
University of Strasbourg	201	1
University of Münster	226	1
Queens University of Belfast	251	1
University of Montpellier	251	1
University of Canterbury, NZ	301	1
University of Waikato	301	1
University of Florence	351	1
Beijing Agricultural University	N/A	1
Massey University, NZ	N/A	1
Middlesex University	N/A	1
Moredun Research Institute, Edinburgh	N/A	1
National Academy of Sciences of Ukraine	N/A	1
National Institute for Medical Research	N/A	1
Strathclyde University	N/A	1
Universidade Federal de Minas Gerais, Brazil	N/A	1
University of Greenwich	N/A	1
University of Paris, Sorbonne	N/A	1
University of Technology of Compiègne	N/A	1
University of Zimbabwe	N/A	1