Woerdeman, Dara L.; Rodgers, Yana van der Meulen

Article

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Dara L. Woerdeman, Yana van der Meulen Rodgers*

Work Styles, Attitudes, and Productivity of Scientists in the Netherlands and the United Kingdom: A Comparison by Gender**

With scientific research growing increasingly multidisciplinary in nature, team playing and communication skills have become critical in the achievement of scientific breakthroughs. This study adds valuable evidence to the oft-cited "productivity puzzle" in the sciences by comparing the work styles, attitudes, and productivity of female and male scientists. The application of t-test analysis to data on scientists from the United Kingdom and the Netherlands indicates that women report relatively higher abilities in communication skills and teamwork than men. Also, both female and male scientists report difficulties in balancing work and family responsibilities, but proportionately more women than men rely on outside sources of childcare. A separate distribution analysis of academic productivity demonstrates substantial overlap between men and women in the number of scientific publications per year. These results add support to mounting pressure for policy reforms that effectively support the retention and advancement of women in the sciences.

Key words: **Skills, Workplace Diversity, Technical Innovation, Scientific Output, Women in Science, Science in Europe**

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* Dara L. Woerdeman, Ph.D., Department of Physics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104, USA, e-mail: woerdeman@drexel.edu.

Corresponding author: Yana van der Meulen Rodgers, Ph.D., Department of Women's and Gender Studies, Rutgers University, 162 Ryders Lane, New Brunswick, NJ 08901, USA, e-mail: yrodgers@rci.rutgers.edu.

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1. Introduction

Creativity leads to innovations, higher productivity, and ultimately, to economic growth. Human factors govern scientific innovation, with creativity across industries as an important factor in the stimulation of innovation in all its forms.[1] Innovation, in turn, contributes to competitiveness and economic growth. A variety of ways of thinking and backgrounds are needed for an environment in which fruitful ideas can prosper. A broader participation in the scientific workforce is the "surest strategy for bringing the best ideas, highest creativity, and greatest innovation to the science, technology, engineering, and mathematics enterprise and the service of the nation," (CEOSE 2004: xv).

Cultural factors can also have a direct impact on scientific output and productivity, and cultural differences between the United States and Europe have been linked to differences in scientific productivity. In comparison with Americans, Europeans are notably less inclined to risk failure.[2] The same is true for companies in terms of their willingness to be bold and experimental, and their general attitudes toward risk. However, the increasing demand on personnel to continually adapt their skills to the requirements of the labor market has provided impetus for many on both continents to acquire new knowledge and skills. European institutions have become the source of a growth in the number of high quality publications, and a growing amount of basic research is originating from European laboratories (TFFAI 2005).

Questions about how to diversify the scientific workforce have gained attention in recent years in academic circles, policy discourse, and the media.[3] A large literature, based mostly on American statistics, reveals numerous factors that influence women in scientific and technical disciplines, and why far fewer reach high positions.[4] European countries exhibit the same pattern, as women remain under-represented in Europe's professional scientific employment across the business sector and academia (European Commission 2005). The low female representation comes at a cost because women bring a distinct set of skills, work styles, and attitudes to the table that can potentially affect productivity at all levels.

The lack of consensus on the "productivity puzzle" in science leaves open the question of whether gender differences in productivity do exist, and if so, the path by

1 A large theoretical and empirical literature in economics has examined the importance of innovation in stimulating productivity and economic growth. This literature has also explored the factors that spur innovation, and Jacobs (2005) is an example of recent work on the links between creativity and innovation.

2 For more discussion of cultural differences across countries and attitudes toward risk, see Thurow (1999) and Statistics Netherlands (2004).

3 Examples of papers about the status of women in the sciences in Europe and policy reforms to advance European women's careers in the sciences include Dewandre (2002), ETAN (2000), Glover (2001), and Osborn (1994).

4 For comprehensive reviews about women in science, see DiTomaso/Farris (1992), Sonnert/Holton (1995), Xie/Shauman (2003), and Preston (2004).

which these gender differences occur.[5] To address this question, we conduct tests of statistical differences between male and female scientists in work styles, attitudes toward work, and productivity. The work is two-fold. In the first part of the study, we apply t-test analysis to samples of scientists from two western European countries known for their high indicators of scientific output: the United Kingdom and the Netherlands. To construct these samples, we utilize the National Child Development Study for the U.K. and the Organisatie voor Strategisch Arbeidsmarktonderzoek for the Netherlands. These data sets are unique because they have very detailed information on respondents' self-reported communication skills, team-playing ability, attitude toward work, and attitudes toward improving math and technical skills, all of which are known to impact productivity. The data sets also have advantages over specialized surveys used to examine work place dynamics because they are large-scale, nationally-representative samples.

Since these surveys target a broad population of individuals in different job settings and do not contain tangible information about scientific output, we cannot directly test how the observed diversity in attitudes and work styles influence scientific creativity and productivity. To address this point, we focus the second part of the investigation more narrowly on a sample of biology and chemistry professors at various academic institutions in the United Kingdom and conduct a distribution analysis of annual publication rates by gender.

2. Data sources and algorithm for estimating gender differences

2.1 Analysis of Work Styles and Attitudes

The first part of the empirical analysis utilizes large nationally-representative samples of individuals from the United Kingdom and the Netherlands. We focus on these two European countries for several reasons. First, PhDs in science and engineering are typically responsible for the initiation of a country's R&D activities, and the United Kingdom ranks among the top European countries for having a high proportion of PhD graduates in science, math, computing, engineering, manufacturing, and construction. The Netherlands stands out in Europe for having among the highest number of patents per million people in the labor force, and in recent years, researchers in the Netherlands have produced among the highest numbers of publications in scientific journals (Statistics Netherlands 2004). Another reason for focusing on these two countries is that the Netherlands tends to have lower female representation in science, engineering, and technology occupations compared to European averages, while the United Kingdom has above average female representation.[6] These country-level differences in women's representation arise from a number of sources, including the number of professional women working part-time, the share of women who study science and engineering subjects as undergraduates, and the extent to which institu-

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5 Cole/Zuckerman (1984) coined this label for the gender gap in scientific research productivity.

6 See the UK Resource Centre for Women in Science Engineering Technology (2005). This source constructs headcount measures for men and women in SET occupations using the European Union Labor Force Survey.

tional reforms have created new tenure-track positions in academia (European Commission 2002).

The availability of rich datasets also helps to explain the choice of countries. For the United Kingdom, the analysis uses the most recently available wave of the National Child Development Study (NCDS) for the year 2000. The NCDS is proprietary data held by the Joint Centre for Longitudinal Research in the United Kingdom.[7] The first wave of the NCDS was conducted in 1965, with subsequent surveys carried out every five to ten years hence up through the year 2000. For the Netherlands, the analysis uses the most recently available wage of the Organisatie voor Strategisch Arbeidsmarktonderzoek (OSA) labor supply database. The OSA is also proprietary data held by Tilburg University. The first wave of the OSA was conducted in 1985, with subsequent surveys carried out every two years.

Both the NCDS and OSA data sets have advantages over other publicly-available household and labor force surveys because they contain very detailed information about worker characteristics, self-reported skills, and self-reported attitudes toward work.[8] For example, the NCDS has a series of questions about how high respondents rank their ability to communicate with others, work on a team, learn new skills, and work with people of other ethnic and racial groups. We use these survey data to construct a sample of scientists for each country. The sample selection strategy focuses on individuals with narrowly defined job titles that encompass science, engineering, and technical occupations. To identify scientists in the NCDS, we use three-digit level Standard Occupational Classification (SOC) codes from 1990 and four-digit level Standard Industrial Classification (SIC) codes from 1992. Appendix Table 1 contains a complete list of all scientific occupation titles and the resulting sample sizes for the U.K.

Most categories are based only on SOC codes, with the following exceptions. The three teaching occupations (SOC 230, 231, and 233) have been limited to those indi-

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7 The full citation for this data collection is Joint Centre for Longitudinal Research, *National Child Development Study and 1970 British Cohort Study (BCS70) Follow-ups, 1999-2000* [computer file]. *2nd Edition.* Colchester, Essex: UK Data Archive [distributor], January 2003. SN: 4396. The data depositor is comprised of the University of London, the Institute of Education, and the Centre for Longitudinal Studies. The Principal Investigator is the Joint Centre for Longitudinal Research. The data collector is the National Centre for Social Research. The sponsors are the Economic and Social Research Council, Office for National Statistics, Department for Education and Employment. Basic Skills Agency, and the University of Essex. The original data creators, depositors, sponsors, and the UK Data Archive bear no responsibility for further analysis or interpretation of this data collection.

8 The self-reported measures of ability could reflect self-esteem and confidence rather than actual performance indicators. However, the NCDS and OSA data are still expected to yield realistic measures of communication skills and team playing ability. These performance attributes correlate closely with self-esteem and confidence for both men and women. Self-reported measures are widely used tools across disciplines, and there is little consensus on the degree to which potential bias affects the validity of results. See Bradburn/Sudman (1988) for more discussion.

viduals with higher degrees in the sciences. We used education background to narrow the teaching occupations down to scientists because individuals in these occupations mostly list "education" as their industry, thus providing no information about whether the field is science or humanities. Note that the NCDS includes 419 individuals in the teaching occupations (SOC 230, 231, and 233). After we reduce this group of teaching professionals to just those individuals with first or higher degrees in the sciences, we are left with 78 individuals. Approximately half of the individuals dropped do not report areas of study, and the remaining half report areas of study in the humanities and social sciences. The last three categories in Appendix Table 1 are based on all other professional jobs in SIC categories that strictly encompass industries in science, engineering, and technology.

After dropping from the sample of scientists those individuals who did not respond to the questions about skills and attitudes toward work, we are left with a sample size of 1758 individuals for the United Kingdom. Almost one quarter of the sample is female, a share that is similar to the 24 percent figure published in readily available sources for the percent female in the U.K.'s science, engineering, and technology occupations.[9] The procedure for constructing the sample of Dutch scientists is similar. To identify scientists in the Dutch OSA labor supply database, we use three-digit level occupational codes ("Standaard Beroepenclassificatie") from 1992.[10] After dropping from the sample those individuals who did not answer the questions about attitudes toward work, we have a sample size of 503 Dutch scientists, and 116 of those scientists are female.

As shown in the appendix table, and consistent with observed patterns in other countries, there are proportionately fewer women in engineering and physics than in chemistry and biology, but even so men still outnumber women.[11] In terms of concentration by gender, both men and women in the sample tend to cluster in managerial jobs that involve computer systems and data processing, as well as computer analysts and programmers. Despite the much larger sample size for men, women actually outnumber men in lower-ranking job categories within the sciences, including secondary education teachers, pharmacists, and lab technicians. As with the U.K. data, within this sample of Dutch scientists the women tend to cluster in secondary school jobs, associate professional occupations, and in supporting technical positions.

2.2 Analysis of Productivity

The second part of the analysis examines scientific output according to publication records collected by the authors. We use the quantity of publications as a measure of output among academics in the sciences. Publication count has its limitations as a

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9 UK Resource Centre for Women in Science Engineering Technology (2005).

10 Because the job titles are similar to those of the United Kingdom, in the interest of conserving space we did not construct a second appendix table for the Netherlands. The list of occupational titles for the Dutch sample is available upon request.

11 See Reskin/Roos (1990) for a closer look at reasons for the progress that women have made, and have not made, in gaining access to predominantly male occupations.

measure of productivity, since it does not provide information on a publication's impact or the individual contribution of each of the authors on a single publication. Yet publication quality, as measured by the number of times a publication is cited, is also a flawed indicator.[12] Others have enumerated drawbacks to using cumulative measures of publication output over short-term measures of publication output (Xie/Shauman 1998). However, neither measure accounts for the rapid increase in publication output that a senior professor typically achieves once he or she is in a position to hire and retain experienced research scientists.[13] Despite the shortcomings, the quantity of publications remains the most widely used measure of research productivity (Fish/Gibbons 1989; Sonnert 1995).

We examine the academic records of faculty from three chemistry departments and three biology departments at five universities in the United Kingdom, to assess how the publication rate of women faculty compares to that of their male colleagues. The universities are the Imperial College of London, University of Cambridge, University of Newcastle, University of Oxford, and the University of Sheffield. If a full-length curriculum vita is not available on the scientist's website, we use an alternative method to count publications based on the scientist's abridged list of selected publications (ranging anywhere from 3 to 17 publications), as described below. In both cases our publication numbers include articles published in refereed journals, chapters in edited volumes, books, and monographs.

The algorithm is designed to estimate publication output from the scientist's self-reported list of selected publications. If there are three or more years between the earliest publication listed and the next earliest publication included in the list of selected publications, the earliest publication in that list is deliberately not included in the calculation. For example, if the list of selected publications contains publications from 1996, 2001, 2002, 2003, and 2004, only the publications from 2001 through 2004 are counted and averaged over the four-year period. Moreover, there are faculty profiles, which have not been updated in over a year. In such cases, publications from 2005 (or possibly earlier) are not included in the calculation. Similarly, if the information on a scientist's website is incomplete, his or her data are not included in the publication count. As not all websites are updated annually, we do not average beyond the range of years reported in the selected publications list. Out of the 298 faculty profiles analyzed, 28 men and 2 women added no new publications to their list after the year 2000.

When the full-length curriculum vita was used, publication number was computed by taking an average over the duration of the scientist's career. First-hand knowledge

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12 In particular, see Ferber (1986, 1988) for arguments that citations do not adequately capture the quality of scholarship, particularly when the proportion of women in a discipline is small.

13 Another drawback to publication counts as an indicator of productivity is that women can face inequalities in having publications accepted. This argument is supported with findings in Ferber/Teiman (1980) that the acceptance rate for papers written by women relative to men is greater in economic journals that have double-blind referee procedures compared to journals without the double-blind procedure.

tells us that this approach more accurately represents the scientist's raw productivity in diverse settings, and also lessens our dependence on numerical corrections.

3. Attitudes and work styles across scientific occupations

3.1 Teamwork and Communication Skills

Tests of statistical differences between male and female scientists in attitudes and work styles yield new evidence on the potential benefits of greater diversity in the scientific workplace. Of greatest interest are the attributes that enable the scientist herself and those around her to be productive. Since the underlying data sets are both general surveys we must use proxies for approaches to science, drawing on information for self-reported skills and attitudes toward work. The data also reflect the challenges that men and women face in juggling a career in science with family responsibilities. The remainder of this section reports sample means by gender for these variables and the results of t-tests for gender differences that are different from zero.

Table 1 reports results for the United Kingdom. Survey questions, sample means, and gender differences are reported according to five major categories that are relevant for attributes affecting scientific productivity, both positively and negatively. Some of the strongest and most striking gender differences are found in the first category, "Ability to communicate and work with other people." Results show that women are consistently more likely to self-report higher ability levels to communicate with other people, work in a team, look after people, and work with people of other races. All of these gender differences are significantly different from zero at the 1% level (two-tailed tests).

For example, on a scale from one (the strongest ability) to four (the weakest ability), female scientists on average rank their ability to communicate with others as 1.25, while men report an average ranking of 1.33. The difference between men and women, 0.08 points, is statistically significant at the 1% level. The large difference between men and women in the ability to look after people (1.77 for women compared to 2.24 for men) clearly reflects social norms that women take on nurturing roles. Yet one could also interpret this result as female scientists reporting a stronger ability to supervise other people. In this first section, women agree more strongly than men that they wouldn't mind working with people from other races, and women disagree more strongly than men that they "do not want another race person as my boss."

Further insight on attitudes and skills among male and female scientists is provided in Table 2, which report t-test results for the Dutch sample of scientists. Because the Dutch survey is unrelated to the U.K. survey, these questions are quite different. Note also that the U.K. and Dutch surveys have the opposite coding schemes for the levels of agreement and disagreement with the various statements. For example, strongly disagree is coded as a five in the U.K. and a one in the Netherlands. Rather than recode one of the surveys, we opted to retain the original coding for each country's responses. Largely because the Dutch sample size is considerably smaller, not as many of the questions yield responses that are significantly different between men and women.

Table 1: Gender differences in self-reported skills and attitudes among U.K. scientists (Source: Authors' computations from the National Child Development Study for the year 2000)

	Mean Response		*M-F*	*Standard*
	Male	*Female*	*Difference*	*Error*
1) Ability to communicate and work with other people				
How good are you at communicating with others?	1.33	1.25	0.08***	(0.03)
1=good 2=fair 3=poor 4=don't have skill				
How good are you at working in a team?	1.22	1.16	0.06***	(0.02)
1=good 2=fair 3=poor 4=don't have skill				
How good are you at looking after people?	2.24	1.77	0.48***	(0.05)
1=good 2=fair 3=poor 4=don't have skill				
I wouldn't mind working with people from other races.	1.54	1.40	0.14***	(0.04)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
I do not want another race person as my boss.	4.14	4.33	-0.19***	(0.05)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
2) Self-confidence in math, problem solving, and technical skills				
How good are you at the use of numbers?	1.29	1.41	-0.11***	(0.03)
1=good 2=fair 3=poor 4=don't have skill				
How good are you at problem solving?	1.21	1.36	-0.15***	(0.03)
1=good 2=fair 3=poor 4=don't have skill				
How good are you at working with finance/accounts?	1.78	1.86	-0.09**	(0.04)
1=good 2=fair 3=poor 4=don't have skill				
How good are you at the use of computers and IT?	1.36	1.63	-0.26***	(0.04)
1=good 2=fair 3=poor 4=don't have skill				
How good are you at using tools properly?	1.44	1.66	-0.22***	(0.03)
1=good 2=fair 3=poor 4=don't have skill				
Computers enrich the lives of users.	2.39	2.46	-0.07	(0.05)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
3) Initiative to invest in new skills				
How good are you at learning new skills?	1.26	1.27	-0.01	(0.03)
1=good 2=fair 3=poor 4=don't have skill				
Learning new things boosts confidence.	1.74	1.70	0.04	(0.03)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
Effort of getting qualifications more trouble than it's worth.	4.13	4.29	-0.16***	(0.05)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
Learning to use a computer more trouble than it's worth.	4.28	4.26	0.02	(0.04)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				

Continued on next page.

	Mean Response		*M-F*	*Standard*
	Male	*Female*	*Difference*	*Error*
4) Willingness and ability to combine family and career				
Mother and family are happier if she goes out to work.	3.39	3.25	0.14***	(0.04)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
Having children interferes with parents' freedom.	2.65	2.90	-0.25***	(0.06)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
Kids benefit if mum has a job outside the home.	3.02	2.73	0.29***	(0.04)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
Dad earns the money, mum stays home.	3.79	4.29	-0.51***	(0.05)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
People with no kids are missing out.	3.06	3.38	-0.32***	(0.06)
1=str. agree 2=agree 3=neutral 4=disagree 5=str. disagree				
How often do you work during the hours of 6pm-10pm?	2.03	2.25	-0.22***	(0.07)
1=1x/week 2=1x/month 3=less than 1x/month 4=never				
How often do you work during the hours of 10pm to 4am?	3.26	3.27	-0.01	(0.06)
1=1x/week 2=1x/month 3=less than 1x/month 4=never				
How often do you work during the hours of 4am to 7am?	3.31	3.39	-0.08	(0.06)
1=1x/week 2=1x/month 3=less than 1x/month 4=never				
How often do you work weekends?	2.64	2.69	-0.05	(0.06)
1=1x/week 2=1x/month 3=less than 1x/month 4=never				
5) Self-reported feeling of well-being				
Are you tired most of the time?	1.75	1.61	0.14**	(0.03)
1=yes 2=no				
Are you often miserable or depressed?	1.89	1.85	0.04**	(0.02)
1=yes 2=no				
Do you often get bad headaches?	1.94	1.84	0.10***	(0.02)
1=yes 2=no				
Do you often get worried?	1.66	1.54	0.12***	(0.03)
1=yes 2=no				
Are you easily upset or irritated?	1.86	1.79	0.08***	(0.02)
1=yes 2=no				
Sample size	1353	405	1758	

Note: The final two columns report results from t-tests for gender differences that are significantly different from zero. The notation *** indicates that the difference between males and females is significantly different from zero at the 1 percent level and ** at the 5 percent level. The corresponding questions are printed in boldface to help guide the eye.

Table 2: Gender differences in self-reported skills and attitudes among Dutch scientists (Source: Authors' computations from the Organisatie voor Strategisch Arbeidsmarktonderzoek for 2002)

	Mean Response		*M-F*	Standard
	Male	*Female*	Difference	Error
1) Attitude Toward the Job				
I enjoy my work everyday.	4.42	4.56	-0.14*	(0.08)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
There is a pleasant atmosphere at my work.	4.13	4.22	-0.10	(0.10)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I am appreciated by my management/boss.	3.99	4.11	-0.13	(0.10)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I get support from my management/boss.	3.85	3.82	0.03	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
2) Leadership Characteristics				
I work with people (patients, clients, students).	1.34	1.13	0.21***	(0.05)
1=yes 2=no				
I can develop and grow professionally at my work.	3.78	4.08	-0.30***	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
My work provides enough perspective for my future career.	3.44	3.31	0.12	(0.13)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I have sufficient control over the content of my work.	3.99	4.03	-0.05	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I can organize my own work.	3.96	3.80	0.16	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I know exactly what is expected in my work.	4.37	4.35	0.02	(0.08)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
3) Constraints on Work Performance				
I can decide in which sequence to perform my tasks.	3.81	3.54	0.27**	(0.12)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I can decide my own work speed.	3.81	3.38	0.43***	(0.12)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I often feel there is not enough time.	2.94	3.18	-0.25*	(0.14)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I feel tired when I wake up and think about another day at work.	1.82	2.06	-0.24**	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
My work is emotionally draining.	1.81	2.27	-0.46***	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I can coordinate my work times and home times.	4.01	3.99	0.02	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I work under much time pressure.	2.87	2.90	-0.03	(0.13)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
I feel burnt out from my work.	1.76	1.69	0.07	(0.11)
1=str. disagree 2=disagree 3=neutral 4=agree 5=str. agree				
Sample size	387	116	503	

Note: The final two columns report results from t-tests for gender differences that are significantly different from zero. The notation *** indicates that the difference between males and females is significantly different from zero at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. The corresponding questions are printed in boldface to help guide the eye.

Among the questions about attitudes toward the job, female scientists are significantly more likely than their male counterparts to agree that they enjoy their work everyday.

However, other questions related to level of satisfaction with the job (including atmosphere on the job, feeling appreciated by management, and getting support from management) yield responses that are similar for men and women. The finding that Dutch male and female scientists have similar responses about receiving support at work may be masking differences within occupations. In particular, Brouns (2000) argues that across university departments in the Netherlands, women appear to face more difficulties in securing prestigious grants in the "softer" natural science departments, including biology, oceanography, and the earth sciences. In contrast, women appear to face a favorable bias in the "exact" science departments, including physics, mathematics, and astronomy.

Consistent with the teamwork results for the U.K., the second section of Table 2 shows that Dutch female scientists are significantly more likely than male scientists to work with people. Female scientists also show stronger agreement with the statement that they can develop and grow professionally at their work. Other questions about level of control at work and potential for leadership show similar responses for men and women.

3.2 Evidence on Constraints

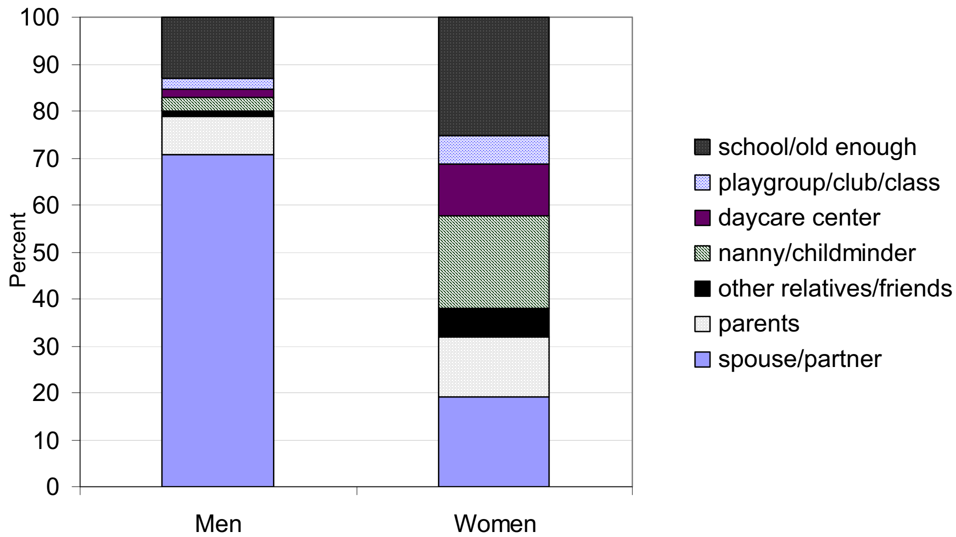
Although female scientists in the U.K. value their communication and people skills, they have lower self-confidence in their math and technical skills. Table 1 shows that for five questions on the using numbers, problem solving, working with financial information, using information technology, and using tools properly, women consistently perceive that they have lower skill levels than their male counterparts. Again, all the differences between men and women are statistically significant. These responses are consistent with a large literature that girls are often discouraged from the pursuit of math and science subjects early in primary and secondary school. Of these five questions, the smallest gender gap is in the area of working with financial information, while the largest gender gap is in the area of computers and information technology.

In direct contrast, as shown in the third section of Table 1, male and female scientists in the U.K. show very similar initiatives to invest in new skills and retraining during their careers. Men and women appear to be equally positive about improving their math and technical knowledge and to hone their skills in order to raise their productivity. If anything, women are more likely to put in the effort to gain new qualifications, as indicated by their stronger disagreement with the idea that "the effort of getting qualifications is more trouble than it's worth." Given these rather similar attitudes toward retraining and learning skills in the face of relatively large gender gaps in self-reported abilities to work with computers, the results suggest potential benefits for on-the-job training and new teaching strategies with greater focus on information technology.

Another strong set of gender differences appear in attitudes toward combining career and family. As shown in the fourth section of Table 1, female scientists in the U.K. are significantly more supportive of the idea that they can work and raise children. Female scientists showed stronger agreement than their male counterparts with the idea that the mother and the family are happier if she goes out to work, and also with the idea that the children benefit if mum has a job outside the home. In contrast, male scientists are more likely to agree with the ideas that having children interferes with parents' freedom, and dads work for money while mothers stay at home.

These differences in attitudes correspond closely with data on who actually takes care of scientists' children. The NCDS provides information on the usual childcare arrangements for children ages zero to fourteen. As shown in Figure 1, male scientists rely primarily on their spouses or partners to take care of their children, while female scientists rely on a host of other child care options. About 70 percent of male scientists who have young children report that their spouse cares for the children during the day, while fewer than 20 percent of female scientists turn to their spouses as the primary source of child care. Female scientists rely primarily on nannies, babysitters, and school as the primary sources of care for their young children during working hours.

Figure 1: U.K. scientists with young children: Who cares for the children?
(Source: Authors' tabulations from the National Child Development Study for the year 2000)



Note: The figure illustrates the share of male scientists and female scientists who report each option as the usual childcare arrangement for any children they have who are ages zero to fourteen.

Family responsibilities help to explain why women are less likely than men to work between 6:00 and 10:00 in the evenings. As shown in the fourth section of Table 1, men reported a higher frequency of working during the dinner and evening hours compared to women. Yet these gender differences become insignificant after 10:00pm and for the weekends. Collectively, women's responsibilities at home and at work could help to explain why women tend to self-report higher levels of stress and fatigue. As shown in the fifth section, women are more likely than men to self-report signs of stress, such as feeling tired, feeling miserable, getting headaches, feeling worried, and becoming easily upset or irritated.

As shown in Table 2, Dutch female scientists feel more constrained than their male counterparts in the ability to decide in which sequence to perform their job priorities. Women also report more constraints in decisions about their work speed. Consistent with the results for the U.K., Dutch female scientists are more likely to show signs of fatigue and to agree that there is not enough time to complete their work. The balance of work and family appears to be taking a toll on self-reported feelings of well-being, an argument that is consistent with survey findings in DiTomaso *et al.* (1993) that female scientists and engineers have more difficulty with the care of dependents than their male counterparts. Pressures to accumulate international experience in the face of limited abilities to move and travel can also explain some of these differences in stress levels (Ackers 2004). Feelings of stress and lack of time may also arise from on-the-job characteristics. In particular, Fox (2001) argues that women approach science with more attention to detail and have a greater tendency to confirm findings, both of which take extra time.

4. Productivity among scientists in academia

For practical reasons, we analyze the research output of PhD scientists at British universities only. Presented in Figure 2 is a profile of the publication output of 298 biologists and chemists from five different universities in the U.K. As it is difficult to make direct comparisons between faculty members at different stages of their career, we normalize our data by computing the average number of publications generated per year by each scientist. In Figure 2, faculty members are each assigned an observation number on the X axis. Panel A reports observations from faculty lists of selected publications, and Panel B shows observations from curriculum vita. In addition, black symbols depict the publication output of female faculty, while white symbols represent the publication output of male faculty.

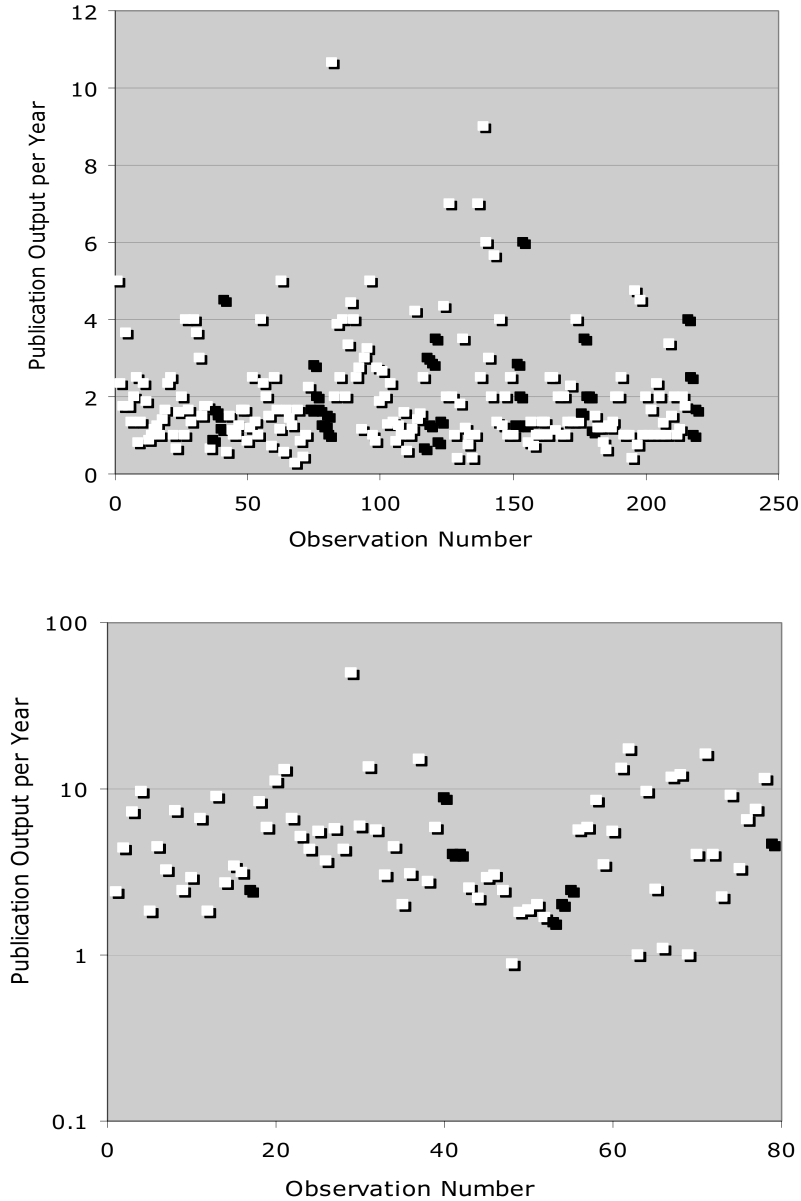
The data in Figure 2 lead to several conclusions. First, faculty members exhibit a large variability in publication rates. From lists of selected publications (Panel A), publications per year range from less than one to six and higher, and this spread grows considerably for observations gained from curriculum vita (Panel B). The figure also confirms the fact that the majority of academic positions in science departments across the U.K. are held by men. In our sample, the male-to-female ratio is seven to one. This recent snapshot is consistent with results in Rich (1999) that even though the level of segregation among male and female faculty in U.K. universities has declined somewhat since the early 1980s, the decline has been quite small and segregation remains a salient feature of university faculty.

Despite the skewed distribution by gender in faculty positions, the results do not reveal statistical differences in publication output among male and female faculty. In both Panels A and B, the range of the black symbols falls well within the range of the white symbols, which tells us that women are no less productive than men. The overlap is evident despite the fact that we do not control for academic rank. As the highest-ranking faculty positions are predominately held by men, the bias, if any, would be in favor of men. The extremely high points in Panel B (for ten or more papers per year) correspond with senior male professors with rather large research groups. In the selected publications plot, such extremes could correspond to scientists who list at least 3 publications in a single year. It is a well-established fact within the scientific community that a critical jump in publication output is likely to occur once a certain level of knowledge is acquired internally within the research group, and the number of researchers within that research group reaches a steady state (Adams *et al.* 2005).

Figure 2: Normalized publication output in a sample of U.K. academic scientists

Panel A. Observations from lists of selected publications

Panel B. Observations from curriculum vita



□ = male
■ = female

Note: Values were extracted from authors' collection of publication records of 298 PhD biologists and chemists currently employed at one of five different universities in the United Kingdom.

5. Discussion

Our analysis of work styles and attitudes among British and Dutch scientists indicates that women report relatively strong abilities in team work and communication, and they are relatively good at supervising other people and working in racially-diverse settings. The results are consistent with findings, across a number of disciplines, that women are stronger team players and communicators than men.[14] More broadly, our findings support those of Barinaga (1993) and Morell (1993), who argue that female scientists have a different style compared to their male counterparts. These traits have become more valuable in the business enterprise sector and in academia, particularly as informal networks have taken on more important roles compared to more traditional hierarchical systems.

Although we cannot directly test how the observed diversity in work styles and attitudes impacts scientific productivity, we can look to a number of useful studies that have linked team playing, collaborative efforts, and communication skills to increased productivity. For example, Bayer and Smart (1991) use data on number of publications among U.S. academics in chemistry to argue that the scientists with greater professional success are team players. In particular, scholars who predominantly lead or participate in multi-authored research papers have significantly more total publications than authors whose records are more balanced with single-authored research papers. Adams *et al.* (2005) also provide evidence linking team-playing with improved productivity. Among the top U.S. research universities, scientists who have earned high-profile awards participate in larger teams, and both scientific output and scientific influence increase as the size of scientific teams grows. A final example links increased productivity with the ability to work in diverse settings. Cordero *et al.* (1996) conducted a specialized survey of professional scientists and engineers in the United States and found evidence that white technical professionals have more patents when they work in racially balanced groups.

Our results also indicate that both female and male scientists in the U.K. and the Netherlands report difficulties in balancing work and family responsibilities. However, a greater percentage of women are forced to rely on outside support than their male colleagues, and women self-report higher levels of stress associated with the family-work balance. These findings for scientists in the U.K. and the Netherlands are consistent with arguments in the European Commission (2003) that more women need to be attracted to research in science and engineering through improved systems in industry and academia that support a healthy balance between work and family. Work policies that meet the needs of scientists who return to professional research after time away for family reasons will also ease the constraints facing women in science. In spite of these challenges, our data show that women scientists are able to keep pace with their male colleagues in terms of scholarly productivity.

This study's results for academic productivity among British scientists demonstrate substantial overlap between men and women in their annual publication rates. This finding is consistent with recent research in Xie and Shauman (1998, 2003)

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14 For a comprehensive and cross-disciplinary review of this literature, see Fisher (1999).

documenting considerably smaller gender differences in publication output compared to earlier gaps reported in Cole and Zuckerman (1984). A growing consensus has emerged that most of the gender gap that still exists in research productivity can be explained by gender differences in years of experience, rank, institution, field, teaching hours, research funding, marital status, and number of children.[15] Our close investigation of scientists in the United Kingdom reveals that this list of explanatory factors can be expanded to include a rather subtle factor related to the synergistic effects of larger research groups. In particular, the majority of the scientists who publish on the order of ten or more articles per year also benefit from having a well-established research group with a growing knowledge base and a team of researchers who generate a continuous flow of publications.

These results help to bolster on-going discussions of policy and institutional reforms that support diversity in scientific education and employment. Recommended changes for successful institutional transformation target a number of issues, including curricular reforms, new approaches to teaching, an increase in mentoring opportunities, adoption of affirmative action policies, and improved access to training for non-traditional careers (CEOSE 2004; Malcom 1996). The profession as a whole can benefit from the employment and retention of scientists who view themselves as adept communicators and team players, skills that are known to impact scientific productivity. An increase in diversity in scientific work teams takes on particular importance as scientific research problems have become more multi-disciplinary and complex.

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15 See, for example, Fox/Faver (1985), Long (1992), Xie/Shauman (1998, 2003), Stack (2004), and Fox (2005).

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Appendix

Table 1.: Sample of Scientists (U.K. National Child Development Survey, 2000)

Occupation Label	*SOC 90*	*No. Men*	*No. Women*
Managers in mining & energy	113	8	1
Computer systems & data processing managers	126	133	32
Chemists	200	18	6
Biological scientists & biochemists	201	15	12
Physicists, geologists & meteorologists	202	10	1
Other natural scientists	209	14	5
Civil, structural, municipal, mining & quarry engineers	210	41	3
Mechanical engineers	211	24	0
Electrical engineers	212	10	2
Electronic engineers	213	18	0
Software engineers	214	80	8
Chemical engineers	215	2	0
Design & development engineers	216	60	3
Process & production engineers	217	20	3
Planning and quality control engineers	218	30	4
Other engineers and technologists	219	23	6
Medical practitioners	220	55	47
Pharmacists/pharmacologists	221	5	19
Ophthalmic opticians	222	3	4
Dental practitioners	223	9	6
Veterinarians	224	3	4
University and polytechnic teaching professionals in science	230	9	6
Higher and Further education teaching professionals in science	231	5	4
Secondary education teaching professionals in science	233	25	29
Laboratory technicians	300	29	30
Engineering technicians	301	33	2
Electrician/electronic technicians	302	19	0
Other scientific technicians	309	27	9
Computer analyst/programmers	320	278	54
Industrial designers	382	15	8
Occupational hygienists & safety officers	396	27	5
Other associate professional & technical occupations	399	21	19
Precision instrument makers and repairers	517	20	2
Computer engineers, installation & maintenance	526	67	6
Dental technicians	592	7	0
Preparatory fibre processors	811	3	0
Other textiles processing operatives	814	8	3
Chemical, gas, & petroleum process plant operatives	820	31	9
Glass & ceramics furnace operatives, kiln setters	823	1	0
Synthetic fiber makers	826	2	1
Inspectors, viewers & testers (metal & electrical goods)	860	33	7
Inspectors, viewers & testers (other manufactured goods)	861	11	11
Other professionals in research & development, natural sciences	73.10*	4	12
Other professionals in architectural, engineering & technical	74.20*	94	21
Other professionals in technical testing & analysis	74.30*	3	1
Total sample size		1353	405

Note: The final three rows indicate all other professionals in industry categories denoted with a *.