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It's a Man's Job: Income and the Gender Gap in Industrial Research

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This study examines differences in income and job performance between women and men in creative, highly skilled jobs tasked with achieving technological inventions. By building on data pertaining to 9,692 inventors from 23 countries, this study shows that female inventors represent only 4.2% of total inventors, and they earn about 14% less than their male peers. The gap persists even when controlling for sources of heterogeneity, the selection of inventors into types of jobs and tasks, and potential parenthood, instrumented by exploiting a source of variation related to religious practices. The income gap is not associated with differences in the quality of the inventions that female and male inventors produce. Thus, even in this human capital–intensive profession, where capabilities and education are important assets, and productivity differentials can be observed, women earn less than men, though they contribute to the development of high-quality inventions as much as men do.

Keywords: research and development; innovation; economics; econometrics
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1. Introduction

Research into the determinants of gender imbalances in wages has a long and continuing tradition. In 2009, female full-time workers in the United States earned 77% as much as male full-time workers (Institute for Women's Policy Research 2009), and in the European Union, Eurostat (2009/2011) cites gender-based wage gaps amounting to 17.5% in 2009 and 16.2% in 2011. Such differentials might have reflected differences in endowments or productivity (Siebert and Sloane 1981, Hwang et al. 1992), yet the wage gap persists, even as the productivity gap has closed over time (Weichselbaumer and Winter-Ebmer 2005). Labor market literature typically relies on wage data to infer productivity (e.g., Topel and Ward 1992), which makes it difficult to disentangle productivity and wage gaps and to determine whether differences in wages might reflect differences in job performance.

To address this challenge, the current study analyzes and compares gender-based wage and job performance gaps among highly skilled, creative workers, namely, "inventors," whose activity results in patented inventions. This group of employees is a relatively homogeneous set of workers, engaged in industrial research and development (R&D), so their job performance (i.e., individual research output) can be readily observed and measured with "objective" indicators based on patents. Remunerations, performance-based incentive systems, and country-specific legal schemes for inventor compensation often stem from these observable indicators of otherwise hard-to-measure effort and ability (Harhoff and Hoisl 2007). In this knowledge-intensive profession, skills and education—or human capital more generally—also are key assets (Amabile 1983) that should constitute the main drivers of income, rather than gender or fertility traits. Empirical evidence confirms that differences in remuneration are tied to differences in individual assets, as indicated by observable performance (Toivanen and Väänänen 2012). Thus, when taking these observable factors into account, there is no reason gender should have any residual explanatory power for inventors' compensation.

Two additional considerations led us to study workers in inventive jobs. First, gender imbalances deserve particular attention in jobs marked by severe underrepresentation of women (Hunt et al. 2013). To deal with impending skills shortages, countries and organizations will need to activate the potential of female (engineers) workers (VDI 2010). Second, creativity, innovation, and technological change are key inputs for economic growth (Romer 1990). A better understanding of the issues facing the actors who constitute the core of the inventive process, and the differences in the rewards they receive for their activity, may inspire policy actions that improve overall participation in R&D activities and outcomes.

Following prior literature in innovation management, labor economics, and personnel economics, we focus on factors that might influence income and inventive performance. The literature review discusses theoretical arguments that apply to our study context, enabling us to derive implications and select factors to include in the empirical analysis, such as education, experience, working hours, and the self-selection of employees into specific types of jobs and tasks. In the resulting, comprehensive empirical analysis, we first determine whether a gap exists between female and male inventors' income, net of several sources of heterogeneity, and we compare this gap against gender differences related to inventive performance. We also explore the role of parenthood to explain wage and inventive performance differentials and account, in our income estimates, for the possibility that fertility and income are jointly determined. Similar to Krapf et al. (2014), we consider inventors active in the profession, while also addressing potential self-selection issues by women.

Our analysis relies on data collected through a large-scale survey of 9,692 inventors from 20 European countries, Israel, the United States, and Japan, conducted between 2009 and 2011. In ordinary least square (OLS) regressions, we show that a gender-based income gap of 12.6% persists in inventive jobs, even after accounting for multiple factors, including education, past productivity, experience, selection into specific work roles and tasks, and individual preferences and motivations to invent. The gap does not disappear even when female inventors are matched with male inventors, so it is not driven by differences between male and female inventors, such as their ages or experience. Parenthood also plays a role: After we instrument for potential fertility, the coefficient of children is negative and statistically significant (it amounts to about 15%) for both male and female inventors, suggesting that men and women in this profession share at least part of the workload associated with raising children. Although most of the factors that we control for contribute to the determination of income, a gap of about 14.5% remains unexplained, and it does not correspond to a gender-based gap in invention quality.

This result is surprising, because in this homogeneous context of R&D workers, where inventive output is observable, we would expect wages to mirror differences in inventive performance. Our results add to literature on the existence of gender-based wage and productivity gaps, with an application to knowledge-intensive jobs. We show that female inventors, though similar to men in terms of performance, are paid less than their male counterparts. In addition, our research contributes to the debate about whether fertility affects income. In the context of our study, lower income is associated with potential parenthood for inventors of both genders. Finally, we confirm that selection and dropout are relevant issues for women. Even in this skill-based, creative profession, women account for only about 4% of our sample, suggesting the need for intervention. One reason for the low participation rates among women is that a small fraction of them pursues the necessary (engineering) studies to enter this profession. In addition, they may recognize that the expected returns from these jobs are lower than those that men can anticipate, and having children may add to this penalty. Thus, government intervention that helps increase the share of women making educational choices that qualify them for inventive jobs is important, but it may not be enough. Women still might not choose to pursue these careers without targeted actions to ensure equal compensations for "equal" employees.

2. Literature Background

In recent decades, researchers from different disciplines have discussed the determinants of gender imbalances in the labor market, including gender productivity and wage gaps. To further this discussion in the context of R&D workers, we provide an overview of existing research on gender imbalances in inventive jobs. Then, we offer a review of prior work on gender-based wage gaps and explain how different determinants apply to our context. This exercise drives the selection of the variables that we control for and provides initial indications of the expected results.

2.1. Gender Imbalances in Inventive Jobs

Existing research on gender imbalances in innovation addresses issues concerning whether women enter jobs in science and engineering, their performance in these jobs, and the reasons they leave. Findings from these studies help explicate the (perceived) roles of women in innovation, which in turn might explain gender differentials in terms of wages and inventive performances.

In an extensive study of differences in the education and qualifications of female inventors in Organisation for Economic Co-operation and Development (OECD) countries, Leszczensky et al. (2013) provide evidence of women's selection into inventive jobs, which starts before their career entry, namely, at university. Women are less likely to choose science, technology, engineering, and mathematics (STEM) degrees, which would qualify them for jobs in R&D or science. Women in STEM fields tend to study chemistry, biology, or biotechnology; they are less likely to pursue physics, mechanical engineering, or electrical engineering studies than men. Moreover, if they enter an inventive job and do not drop out, women are overqualified, compared with men, especially if they have children, and they tend to be overrepresented in part-time jobs (Wetzels and Zorlu 2003).

With a focus on academic careers in life sciences, Ding et al. (2006) find that women patent about 40% less than men do, and they explain this gap in terms of women's more limited links with the industry and a traditional view of academic careers, rather than as a signal of lower research productivity. They find no significant differences in research productivity, operationalized as per article mean citation counts. Women are even ahead of men in terms of the impact factors of journals that publish their research.

Joshi (2014) studies science and engineering teams in industry and finds that in "gender-balanced disciplines," team productivity increases with the share of highly educated women. In "male-dominated disciplines," a systematic underestimation of women's expertise prevents the full exploitation of their potential. This finding is consistent with social role theory, according to which women are considered less competent than men because they are underrepresented in contexts such as R&D (e.g., Ridgeway and Smith-Lovin 1999, Carli 2010). Workers perceived as experts are more likely to influence decisions, take leadership positions, and get assigned to important projects, so they have more opportunities to demonstrate their abilities (Berger et al. 1992, Ridgeway and Smith-Lovin 1999, Bunderson 2003). If women have fewer chances to demonstrate their potential, it could lead to productivity differences in male-dominated jobs. In addition, preconceived ideas about women's potential could generate different returns on similar competences and job performance.

Dissatisfaction with pay and career opportunities may explain women's exits from engineering. Hunt (2016) compares exit rates for men and women from jobs in science and engineering (compared with other fields) and finds that a higher exit rate of women compared with men is driven by engineering rather than science. Moreover, 60% of excess exits are due to female engineers' concerns about pay and career opportunities. Working conditions and family considerations are less of an issue for female engineers. Thus, beyond a selection effect for women in science and engineering, those who enter male-dominated disciplines also are less likely to exploit their full potential. Although there is no clear-cut evidence that this limitation leads female engineers to perform worse than male engineers, it may lead to reduced wages and career opportunities, and thus to higher exit rates (Hunt 2016).

In accordance with these results, our empirical study identifies potential sources of selection of women into inventive jobs; given that we observe only inventors who "survive" in the profession, it also addresses the potential effects that selection may have on our findings. Furthermore, we account for the different roles that female and male inventors take on at work and consider different quality-based indicators to measure inventive performance.

2.2. Determinants of Gender-Based Wage Gaps

We now turn to the determinants of wage differentials in inventive jobs. Unfortunately, direct evidence on gender-based wage gaps in science and engineering jobs related to the production of innovations is scarce. Toivanen and Väänänen (2012) analyze the earnings of industrial inventors and find that they are tied to past productivity (quantity and quality of patents) and that a wage gap of about 20% exists between male and female Finnish inventors. They also note that female inventors receive the same immediate returns on patents (i.e., temporary increase of annual earnings) as men do, but not the same long-term returns (i.e., longer-lasting premiums in earnings after three years). The latter effect explains part of the gender-based wage gap. These findings provide a first indication of a gender-based wage gap in inventive jobs and suggest that past productivity and experience are important factors to account for in the wage equation.

Most closely related to our study context, one stream of research addresses the wage and productivity gaps of scientists in academia. Levin and Stephan (1998) use data from the National Research Council's biennial Survey of Doctorate Recipients between 1973 and 1979 and show that women in academia earn significantly less than men in all technological fields, though in physics and biochemistry, wage gaps have decreased over time. Ginther (2004) confirms that women in science earn less than men. Kelchtermans and Veugelers (2013) analyze gender-related differences in research productivity and find that women exhibit a lower probability of reaching top performance for the first time, which may explain the lower wages of women in science. However, once top performance is reached, there is no gender bias preventing repeated top performance. Unequal employment opportunities and access to top positions add to the explanation. Women are less likely to be promoted (Kahn 1993, Long et al. 1993) and often take part-time jobs to allow them time to care for their families (Ginther and Kahn 2006). These results confirm the importance of accounting for the types of jobs and tasks that male and female inventors, similarly to scientists, select for themselves.

Literature from labor and personnel economics, as well as innovation management, also provides insights into the potential determinants of gender-based wage gaps. Rather than offering an exhaustive review, we discuss selected theoretical arguments according to their relevance for our context. To begin, the neoclassical theory of human capital (Becker 1971, Mincer 1974) argues that human capital factors largely explain wage differentials (England et al. 1994), leaving little to be explained by gender, especially in high-wage jobs that require high levels of skills and education (England 1992). Studies in sociology confirm that the gender-based wage gap almost disappears for men and women

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employed in the same type of job (Tomaskovic-Devey 1993, Kilbourne et al. 1994, Petersen and Morgan 1995). We focus on employees in industrial R&D, which is quite homogeneous in terms of required knowledge and skills, and the human capital factors that determinate wages are mostly observable and can be proxied (with error) by direct indicators such as education or past productivity (Toivanen and Väänänen 2012). Therefore, after taking into account differences in human capital endowments, no gender differences should persist in wages.

Yet skills and education may not account for gender differences in personal attitudes and career preferences. Tsui (1998) notes the influence of negotiation skills in gender-based wage disparities (see also Leibbrandt and List 2015, Babcock et al. 2006, Babcock and Laschever 2003). Personal motivations and preferences influence a person's self-assessment of the type of career suitable for and available to her (Correll 2004). Experimental and personnel economics research provides evidence that men and women differ in their taste for competitive environments (Dargnies 2012), such that women enter tournaments less often than men (Niederle and Vesterlund 2007). Even after controlling for risk-taking behavior and overconfidence, these gender-based tournament gaps remain and are partly explained by differences in people's willingness to perform under pressure (Niederle and Vesterlund 2007, 2011; Niederle et al. 2013; Datta Gupta et al. 2013). Thus, for example, women tend to enter jobs related to administrative support or other services more than managerial jobs (Blau and Kahn 2000), and such selection into less risky positions and tasks then affects wages through risk premiums (Flory et al. 2015, Niederle and Vesterlund 2007).

Similar to tournaments, innovation is characterized by considerable risks, including technological and market failure (Teece 2006), which may drive women away from inventive jobs. Moreover, within the inventive job, inventors can perform an array of activities, characterized by different degrees of riskiness and requests to perform under pressure (e.g., routine and administrative tasks versus cutting-edge technological activities). If the taste for competition is lower among women than among men, women may self-select into more routine inventive activities and tasks, rather than engage in risky, challenging projects. It is therefore necessary to account for factors related to personal attributes, such as risk-taking attitudes, and for selection into particular types of jobs or tasks.

Family commitments, such as the arrival of children, can affect wages too. With pooled cross-sectional data about women 14–44 years of age between 1968 and 1988, Anderson et al. (2003) find a 10% "motherhood wage penalty." Because two-thirds of lifetime wage growth occurs during the first 10 years of employment (Murphy and Welch 1990), women who take maternity leaves at the beginning of their careers are penalized, and this monetary loss is not compensated for over the remainder of their professional lives. A motherhood wage gap also might be ascribed to perceptions that women with children suffer lower productivity (Anderson et al. 2003), or women with children could be less productive in reality than men or women without children, if they must divide their energy between childcare and work (Becker 1985). Other contributions suggest a selection story: Fernandez-Mateo and King (2011) argue, for example, that women who anticipate breaks in their careers choose jobs that allow reentry into the job market, such as those that require general rather than firm-specific skills or knowledge (Becker 1985, Loprest 1992). In addition, roles like motherhood may come into conflict with certain work roles, such that women might prefer jobs that offer predictable working hours at the expense of higher wages (Barbulescu and Bidwell 2013, Brett and Stroh 2003, Stone 2008). Eccles (1994) confirms that women prefer jobs that give them flexibility to accommodate their family needs, even if, when they apply for those jobs, they do not have children.

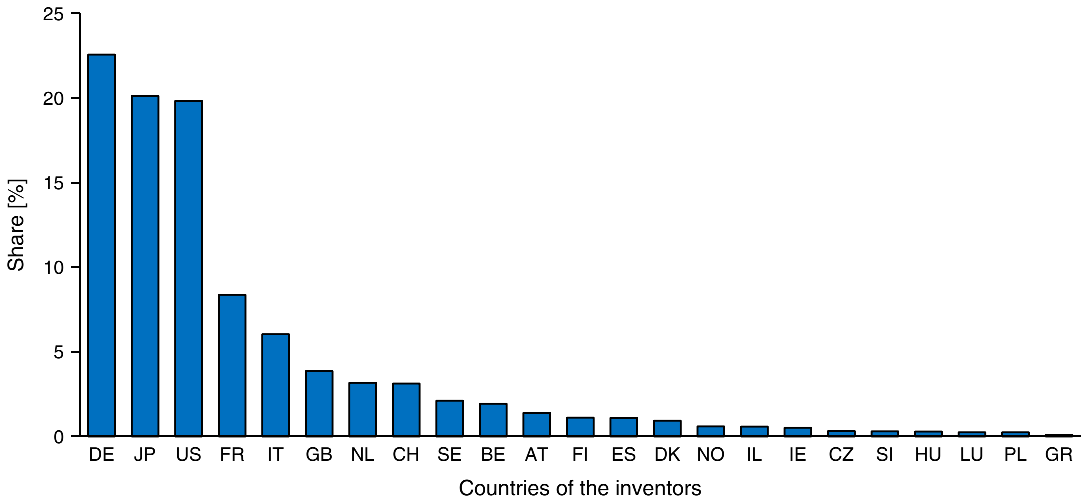
Innovation consists of the generation of new ideas and applications, which requires employees in such jobs to remain up to date or even ahead of general knowledge development and technological progress. Because of the rapid obsolescence of knowledge, (anticipated) maternity leaves or reduced working hours may be more expensive for women in inventive professions than in other jobs, leading to lower wages or selection into more routine tasks rather than tasks dealing with activities at the technological frontier. Subordinating their own careers to their husband's or to the needs of children may be expensive for female inventors as well. In the case that they change employers unwillingly, for family reasons, women are less likely to find a good match than employees who move willingly (e.g., because of a better job offer). A bad match, in turn, decreases productivity and wages (Topel and Ward 1992, Song et al. 2003, de Rassenfosse and Hoisl 2015).

This literature review leads us to incorporate, in our empirical analysis, factors such as inventors' past productivity and experience, human capital endowments, personal attributes (e.g., risk-taking attitudes, motivations to work), and types of jobs and tasks that male and female inventors select into, as well as family commitments.

3. Data and Descriptive Statistics

Our investigation uses data about inventors, defined as workers employed in highly skilled and creative jobs, such as R&D, whose key input is human capital and whose output is (patented) inventions (Walsh and Nagaoka 2009). To collect data about inventors, we used a worldwide survey, associated with a project

Figure 1 (Color online) Distribution of the Home Countries of Inventors ($N = 9{,}692$)

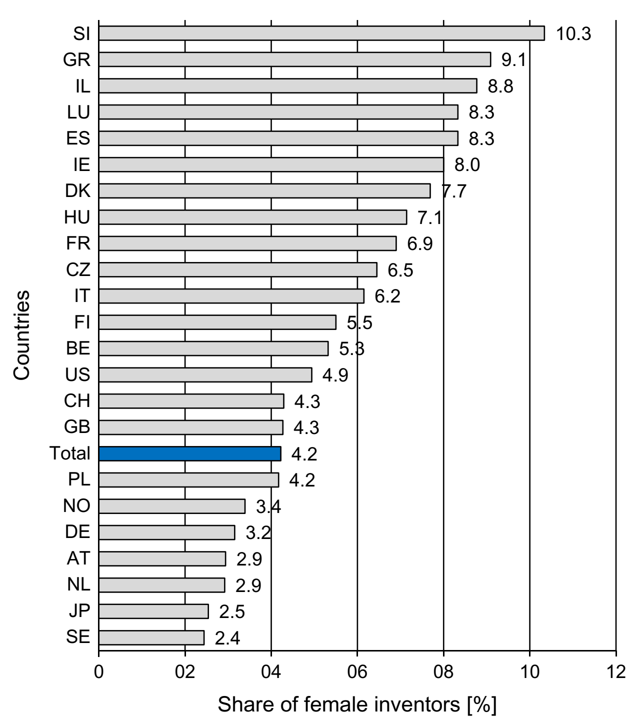


sponsored by the European Commission, "Innovative S&T indicators combining patent data and surveys: Empirical models and policy analyses" (INNOS&T). The survey was conducted between 2009 and 2011. We surveyed inventors from 20 European countries, Israel, the United States, and Japan who were listed on at least one European patent application with priority dates between 2003 and 2005.[1] The database contains information about 22,557 inventors. However, because data about some key covariates were missing, we employed a subsample of 9,692 observations.[2] Figure 1 shows that the largest shares of inventors lived in Germany (22.6%), Japan (20.1%), and the United States (19.8%); the smallest shares came from Luxemburg (0.2%), Poland (0.2%), and Greece (0.1%). The electronic companion to this paper details the sampling procedure and the method for administering the survey (see §EC.1).

This data set provides comprehensive information to characterize inventors and their jobs. Female inventors account for 4.2% of the overall sample, though their share varies across countries. As Figure 2 shows, this share reaches 10.3% in Slovenia, 8.8% in Israel, and 4.9% in the United States, but it falls to 3.2% in Germany and 2.5% in Japan.

The survey also provides information about the annual gross income that inventors earned at the time of their invention, according to the following categories: less than 10,000€, 10,000–29,999€, 30,000–49,999€, 50,000–69,999€, 70,000–99,999€, or 100,000€ or more. We employ the mean value for each category (e.g., 100,000€ for the highest category) and use income as a proxy for wages. Figure 3 shows the distribution of this variable in the sample and for female and

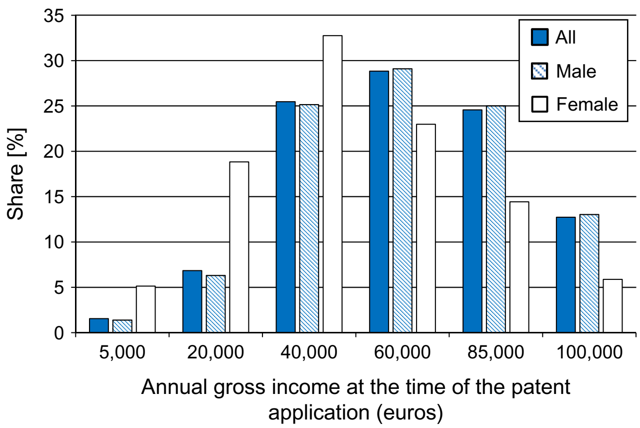
Figure 2 (Color online) Share of Female Inventors by Country ($N = 9{,}692$; **Men** $= 9{,}283$; **Women** $= 409$)



[1] The questionnaire asked inventors questions about one of their patents, chosen randomly from the patent applications with priority dates between 2003 and 2005. They answered the questions about income, patent value, and the work environment with respect to this patent and the year in which the invention underlying the patent took place.

[2] We conducted a nonresponse analysis to test whether inventors (and patents) who completed the questionnaires differed significantly from nonrespondents (the detailed results are summarized in §EC.2 of the electronic companion, available as supplemental material at http://dx.doi.org/10.1287/mnsc.2015.2357). We also performed regressions by including sampling weights, to account for coverage biases (nonrandom selection), nonresponse bias, and selection into our nonmissing variables subsample. The results remained robust, as we show in the electronic companion (§EC.4).

Figure 3 (Color online) Distribution of Income of Inventors ($N = 9{,}692$; Men $= 9{,}283$; Women $= 409$)



male inventors separately. Figure 4 shows the average income of female and male inventors by country and groups of countries. With Table 1, we summarize the descriptive statistics and the results of a chi-square test and t-test for the differences between male and female subsamples. The average inventor's income is 62,552€, with female inventors earning 22% less than male inventors. The distribution of income by gender in Figure 3 confirms that the presence of female compared with male inventors is higher in the left tail and lower in the right tail of the distribution. Figure 4 shows that male inventors earn higher incomes than female inventors in all countries and regions, and the difference between male and female inventors is statistically significant at the 10% level or lower. The only exception pertains to Central and Eastern European countries, for which the sample size is relatively small.

The picture changes for the distribution of inventive performance, which we operationalize as the quality of the inventions that the surveyed inventors produced and measure with three indicators. The first indicator relies on a general requirement of patentability, namely, the *INVENTIVE STEP* underlying the invention (Gambardella and Harhoff 2011). This information, derived from the questionnaire, reflects a Likert scale ranging from "very low" (1) to "extremely high" (5). The second proxy, the number of *FORWARD CITATIONS* that the invention received within five years of the publication of the patent application, came from the Patent Statistical database (PATSTAT) (as of October 2011) (Trajtenberg 1990, Harhoff et al. 1999). The citation variable was adjusted for equivalent patent filings, which means that citations to non-European patent documents, belonging to the same patent family, were distributed among all members of the patent family.[3] The third indicator is the size of the "family" of patents to which the invention belongs;[4] that is, *FAMILY SIZE* refers to the number of countries in which patent protection was sought for the same invention (Harhoff et al. 2003). This variable was also derived from the PATSTAT database (as of October 2011). For each additional country, applicants must pay application, translation, and renewal fees. Thus, whereas the inventive step and the number of citations constitute proxies for the technological value of an invention, family size accounts for its market potential, based on the applicant's investment decision (Putnam 1996, Guellec and van Pottelsberghe de la Potterie 2000).

Figures 5–7 show the distribution of the three quality indicators in the sample, and for female and male inventors separately. Particularly, the distributions of citations are more skewed to the right than the earnings distributions. Moreover, whereas the right tail of the earning distribution is fatter for male than for female inventors, the opposite is true for the three quality proxies: The right tail of the distribution is fatter for female inventors, suggesting that the share of women with high-quality patents is larger than that of men. The t-tests reveal a statistically significant difference between men's and women's forward citations and family size.

We present the correlation matrix in §EC.3 of the electronic companion. Correlations are generally low, so multicollinearity should not be a concern. This intuition is confirmed by an estimation of the variance inflation factors, which reach a maximum of 2.36. The only exception is the correlation between age and experience, which amounts to 0.78, and thus may diminish the statistical significance of these two variables when we include both of them in the regression analysis.

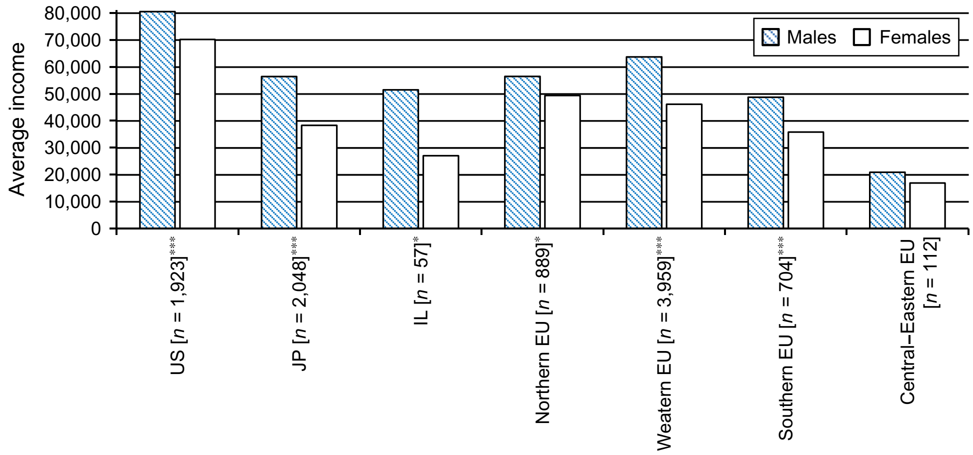
3.1. Demographics and Labor Supply Variables

The primary covariate is gender, which we measure with a dummy variable (*FEMALE*) that takes a value of 1 for female inventors. We also consider the number of children each inventor had (*NUMBER OF CHILDREN*) and control for whether he or she was married or had a cohabiting partner (*MARRIAGE or COHABITING*). As we noted, 4.2% of the respondents are women; 84% of the inventors are married or cohabiting. The mean number of children is 1.5 (median = 2). Female inventors, on average, are significantly less often married (72% versus 85%) and have fewer children (0.9 versus 1.5) than their male counterparts.

[3] In accordance with the work of De Solla Price (1976), who counts the publication of a paper as the first citation, we consider an application for a European patent its first patent citation.

[4] We employ the size of the International Patent Documentation Center (INPADOC) patent family, which measures the number of equivalent patent applications in other jurisdictions that share at least one priority with the surveyed patent. This database is maintained by the European Patent Office and contains information about patent families and the legal status of patent applications (see http://ep.espacenet.com/help?topic=legalstatusqh&locale=en_ep&method=handleHelpTopic, accessed March 6, 2015).

Figure 4 (Color online) Average Income of Female and Male Inventors, by Country or Group of Countries ($N = 9{,}692$)



Notes. US, United States; JP, Japan; IL, Israel. Country groups reflect the United Nations classification (United Nations Statistics Division): Northern EU includes Denmark (DK), Sweden (SE), Norway (NO), Ireland (IE), Great Britain (GB), and Finland (FI); Western EU includes Austria (AT), Belgium (BE), Switzerland (CH), France (FR), Germany (DE), Netherlands (NL), and Luxembourg (LU); Southern EU includes Italy (IT), Spain (SP), and Greece (GR); and Central–Eastern EU includes Czech Republic (CZ), Hungary (HU), Poland (PL), and Slovenia (SI).
$^{*}p < 0.10$; $^{***}p < 0.01$.

Wage and inventive performance differentials may depend on age (*AGE*), so we gathered information about the age of the inventors. We employ four dummy variables to indicate the highest level of education the inventors had earned at the time of their invention: *SECONDARY SCHOOL* or vocational training[5] (i.e., lower secondary level of education), *HIGH SCHOOL* (i.e., upper secondary level of education), *BACHELOR* or *MASTER* (first stage of tertiary education), and *PHD* or *POSTDOC* (second stage of tertiary education). The inventors in the sample are between 20 and 84 years of age. Only 2% do not have a degree higher than secondary school, 8% have a high school degree, 61% earned a bachelor's or master's degree, and 29% have a doctoral or postdoctoral degree. Female inventors are 5.3 years younger than male inventors on average (43.6 versus 38.3 years; significant at 1% level) and reveal significantly higher levels of education, which may reflect their greater likelihood of working in biotechnology or chemical fields, where doctoral degrees are more common. In particular, 41% of female inventors have doctoral or postdoctoral degrees, compared with 28% of male inventors. The relative youth of the female inventors also correlates with their lower likelihood to be married, have fewer children, and have earned more education, because the share of people earning doctoral degrees has increased over time (Jones 2010).

To control for individual inclinations and motivations to work, we employ information gathered through the survey about the importance of career advances and opportunities for better jobs (*ADVANCEMENT REWARD*), a high degree of independence (*INDEPENDENCE REWARD*), and contribution to society (*SOCIETY REWARD*; Likert scales from 1 (not important) to 5 (very important)). The average scores are 2.1 for career motivation and 2.9 for both independence and society-related motivations. Women's scores are significantly higher than men's for all three types of motivations.

The average number of working hours per week (*WORKING HOURS*) and number of hours dedicated to leisure time (*HOURS LEISURE TIME*) also could contribute to the wage and inventive performance gaps, if they indicate women work part-time jobs. Lazear (1976) provides an early comparison of the wage effect of work experience against that of aging and finds that, even after controlling for age, experience exerts an important effect. We therefore control for years of prior inventive activity (*EXPERIENCE*), computed as the difference between the year in which inventors started to conduct research (obtained from the survey) and the year of their surveyed invention. In addition, we capture the inventors' prior productivity (Hellerstein et al. 1996) with a variable that indicates the average number of inventions per year during an inventor's research activity (i.e., number of prior inventions divided by the number of years since the inventor started doing research). To accommodate

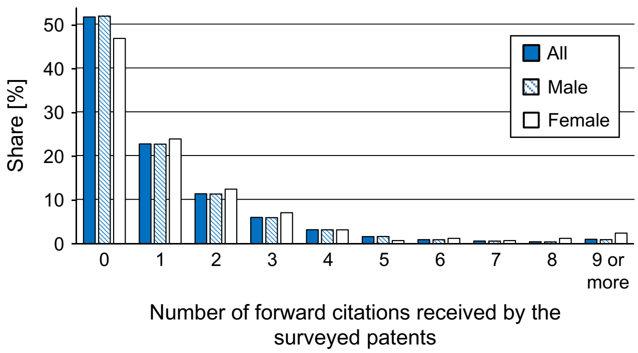
[5] Secondary school (also known as junior high school) refers to the years of education after primary school, typically up to the 9th or 10th grade. Vocational training refers to a two- to three-year program following primary school or lower secondary school. Learning during vocational training typically takes place at the workplace and in vocational education schools (dual system) (see OECD 1999).

Table 1 Descriptive Statistics

	Total sample; N(total) = 9,692				Male inventors; n(male) = 9,283				Female inventors; n(female) = 409			
Variable	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
INCOME***	62,552.10	24,677.40	5,000	100,000	63,147.15	24,468.34	5,000	100,000	49,046.46	25,558.86	5,000	100,000
FORWARD CITATIONS***	1.11	1.94	0	43	1.10	1.91	0	43	1.39	2.53	0	28
INVENTIVE STEP	3.33	0.90	1	5	3.33	0.90	1	5	3.40	0.89	1	5
FORWARD CITATIONS PER INVENTOR	0.53	0.98	0	22	0.53	0.98	0	22	0.54	1.07	0	14
FAMILY SIZE***	28.72	26.40	1	1,014	28.56	26.68	1	1,014	32.27	18.78	1	285
FEMALE (dummy)	0.04	0.20	0	1	—	—	—	—	—	—	—	—
MARRIAGE (COHABITING) (dummy)***	0.84	0.36	0	1	0.85	0.36	0	1	0.72	0.45	0	1
NUMBER OF CHILDREN***	1.47	1.17	0	4	1.49	1.17	0	4	0.87	0.98	0	3
WORKING HOURS***	44.20	15.08	0	80	44.30	15.12	0	80	41.98	14.12	1	80
HOURS LEISURE TIME	13.78	11.06	0	128	13.80	10.97	0	128	14.00	12.85	0	90
AGE***	43.36	9.90	20	84	43.58	9.89	20	84	38.32	8.87	22	70
HIGH SCHOOL (dummy)**	0.08	0.28	0	1	0.09	0.28	0	1	0.06	0.23	0	1
BACHELOR OR MASTER (dummy)***	0.61	0.49	0	1	0.61	0.49	0	1	0.52	0.50	0	1
PHD (dummy)***	0.29	0.45	0	1	0.28	0.45	0	1	0.41	0.49	0	1
EXPERIENCE***	15.64	10.26	0	62	15.83	10.29	0	62	11.25	8.56	0	47
PAST PRODUCTIVITY ADJUSTED**	3.20	9.08	0.02	500	3.24	9.24	0.02	500	2.20	3.99	0.06	50
PAST MOBILITY (dummy)	0.31	0.46	0	1	0.31	0.46	0	1	0.35	0.48	0	1
FIRM SIZE—SMALL FIRM	0.14	0.35	0	1	0.14	0.35	0	1	0.16	0.37	0	1
FIRM SIZE—MEDIUM SIZED FIRM	0.06	0.23	0	1	0.06	0.23	0	1	0.05	0.23	0	1
FIRM SIZE—LARGE FIRM	0.80	0.40	0	1	0.80	0.40	0	1	0.77	0.42	0	1
RD EMPLOYEES	1,326.59	10,084.73	0	500,000	1,345.15	10,272.34	0	500,000	863.75	2,508.23	0	20,000
RD EMPLOYEES MISSING (dummy)***	0.28	0.45	0	1	0.28	0.45	0	1	0.34	0.47	0	1
PUBLIC RESEARCH ORGANIZATION (dummy)***	0.06	0.24	0	1	0.06	0.23	0	1	0.13	0.34	0	1
ADVANCEMENT REWARD***	2.14	1.29	1	5	2.13	1.28	1	5	2.37	1.43	1	5
INDEPENDENCE REWARD**	2.93	1.41	1	5	2.87	1.41	1	5	2.98	1.51	1	5
SOCIETY REWARD***	2.89	1.36	1	5	2.87	1.36	1	5	3.11	1.37	1	5
RISK ATTITUDE***	7.05	2.35	1	11	7.07	2.34	1	11	6.55	2.52	1	5
TIME DEVOTED TO INVENT (share)***	33.04	29.94	0	100	32.42	29.65	0	100	46.98	32.82	0	100
TIME ROUTINE TASKS (share)***	36.55	24.64	0	100	36.74	24.65	0	100	32.23	23.97	0	100
LEADER***	6.29	14.69	0	100	6.43	14.89	0	100	2.96	8.53	0	95
WORK IN R&D DPT (dummy)	0.80	0.40	0	1	0.79	0.41	0	1	0.82	0.38	0	1
TOP MANAGEMENT POSITION (dummy)***	0.06	0.24	0	1	0.06	0.25	0	1	0.03	0.18	0	1
PROJECT SIZE***	13.49	19.05	0	73	13.14	18.79	0	73	21.30	22.65	0	73
PROJECT SIZE MISSING (dummy)***	0.08	0.26	0	1	0.07	0.26	0	1	0.14	0.35	0	1
NUMBER OF INVENTORS***	2.62	1.81	1	20	2.59	1.79	1	20	3.25	2.08	1	13
MY IDEA***	0.46	0.50	0	1	0.47	0.50	0	1	0.25	0.44	0	1
LEISURE TIME RELIGION	0.56	1.10	0	5	0.56	1.09	0	5	0.61	1.17	0	5

Note. $N = 9{,}198$ for *INVENTIVE STEP*.
$^{**}p < 0.05$; $^{***}p < 0.01$ (χ^2 test or t-test of the difference between male and female inventors).

Figure 5 (Color online) Distribution of Forward Citations ($N = 9{,}692$; Men $= 9{,}283$; Women $= 409$)

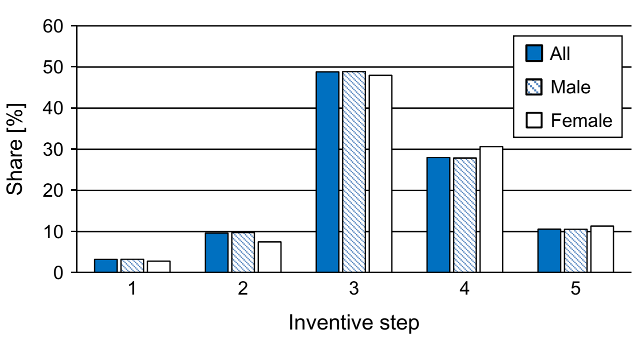


maternity leaves (which reduce women's activity measures), we reduce the years of inventive activity of female inventors by the number of children they had, before calculating the quotient (*PAST PRODUCTIVITY ADJUSTED*). Mobility across employers may signal the availability of outside options for inventors, or a change in the quality of the employee–employer match; the dummy variable *PAST MOBILITY* takes a value of 1 if the inventor had changed employer during the five years before making the invention underlying our survey, and 0 otherwise. All these variables were collected through the survey.

We find that the average number of weekly work hours is 44.2 (44.3 hours for men; 42.0 hours for women; difference significant at 1% level). Leisure time amounts to 13.8 hours per week, with no significant variation across genders. The (adjusted) productivity of inventors is 3.2 on average, and female inventors exhibit lower average prior productivity (2.2) than men (3.2). In addition, 31% of inventors in the sample had changed their employer prior to the focal invention (35% of female inventors; 31% of male inventors).

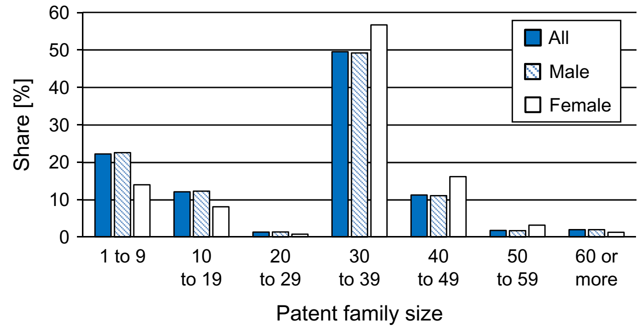
We control for inventors' willingness to take risk: *RISK ATTITUDE* takes values between 1 (completely unwilling to take risk) and 11 (completely willing to take risk). The mean response is 7, and male inventors

Figure 6 (Color online) Inventive Step Distribution ($N = 9{,}198$; Men $= 8{,}835$; Women $= 363$)



Note. 1 = extremely low; 5 = extremely high.

Figure 7 (Color online) Family Size Distribution (Number of Patents in the Family; $N = 9{,}692$; Men $= 9{,}283$; Women $= 409$)



appear slightly more willing to take risks than female inventors. Finally, we indicate whether the inventor works in the R&D or other departments, such as logistics, production, marketing, or human resources; wages may vary across job characteristics and functional areas (Gutteridge 1973). Scientists in the R&D department also may produce patents with different characteristics than employees in other, less research-oriented departments, which also has potential implications for the quality of the inventions. Furthermore, scientists may enjoy their work, such that, all else being equal, they might receive relatively lower wages than other employees, because they "pay to be scientists" (Stern 2004). Female inventors are relatively more likely to be employed in some departments (e.g., marketing, 3%; R&D, 4.4%) than in others (e.g., production, 2.6%). If salaries and inventive performance differ according to placement in specific departments, it would affect the estimated gender gap. The dummy *WORK IN R&D DPT* thus equals 1 if the inventor is employed in the R&D department and 0 otherwise. In our sample, 80% of the inventors work in an R&D department, and the share is higher among female inventors (82%).

3.2. Employer- and Project-Level Variables

We control for variation among inventors employed in firms of different sizes and R&D employees (Schmidt and Zimmermann 1991, Rosenkopf and Almeida 2003). Dummy variables indicate organizations with fewer than 100 employees (*FIRM SIZE—SMALL FIRM*, reference group), between 100 and 249 employees (*FIRM SIZE—MEDIUM SIZED FIRM*), or more than 249 employees (*FIRM SIZE—LARGE FIRM*). The variable *RD EMPLOYEES* is calculated as the number of employees active in R&D in the employer organization. We use a *PUBLIC RESEARCH ORGANIZATION* dummy variable, equal to 1 if the employer is a university or public research institute and 0 otherwise.[6] Eighty percent of inventors are employed by large organizations (more than 499 employees), and their presence in

[6] The "other" group contains private firms, publicly traded companies, foundations, and hospitals.

universities or public research laboratories reaches 6%. Female inventors tend to work more often in public research organizations (13% versus 6%); we found no gender-related differences with respect to firm size or R&D employees.

Large investments in R&D projects typically result in particularly valuable inventions. In equations that estimate the quality of the inventions, we therefore use a variable to capture the size of the project leading to the focal invention (*PROJECT SIZE*), measured as the total labor input needed to produce it. This variable was constructed from responses to the questionnaire, across eight project size categories: less than 1, 1–3, 4–6, 7–12, 13–24, 25–48, 49–72, and 73 or more man-months. We use the mean values of each category (e.g., 73 for the highest category) in our estimates.[7] The average project required 13.5 months, and female inventors worked, on average, on larger projects (21.3 versus 13.1 months). To account for the contribution of the surveyed inventor to the inventive process, we use two variables: the *NUMBER OF INVENTORS* involved in the research leading to the patent (as reported on the patent document), which captures the size of the R&D team, and *MY IDEA*, a survey variable that indicates whether the idea underlying the patented invention originated from the inventor completing the survey. The average number of inventors per patent is 2.6, and it is greater for women than for men (3.3 versus 2.6 inventors). In 46% of the cases (47% for male inventors; 25 % for female inventors), the surveyed inventor had the idea leading to the patent. These shares are consistent with women being part of larger teams than men.

3.3. Types of Jobs and Tasks

Inventors work at different hierarchical levels, such as laboratory assistants or top managers, or might function in dual ladder career systems that provide career chances for engineers without forcing them to take management or administrative positions (Allen and Katz 1986). They might fulfill routine or cutting-edge jobs; the latter are characterized as risky, labor intensive, and idiosyncratic (Holmström 1989). Both the choice of tasks and the type of job can correlate with pay and the quality of the inventive output, so we account for career paths with four variables: the share of working time typically spent on inventing (*TIME DEVOTED TO INVENT*); the share of working time typically spent on routine or less challenging tasks (*TIME ROUTINE TASKS*); the number of others reporting to the inventor (*LEADER*); and whether the inventor had a top management position (*TOP MANAGEMENT POSITION*). We found that 33% of inventors' work time is dedicated to R&D. Female inventors outperform male inventors in this respect, with an average share of time devoted to R&D equal to 47.0%, compared with 32.4% for their male counterparts. The share of time spent on routine tasks averages 36.6%: 36.7% for male and 32.2% for female inventors. In terms of leadership and management positions, the average number of other employees reporting to the inventors is 6.4 for male and 3.0 for female inventors (overall average of 6.3). Finally, 6.3% of respondents had a top management position (6.4% of male and 3.2% of female inventors). All these differences between genders are significant at the 1% level.

3.4. Country of Inventors, Priority Years, and Technological Classes

We control for variations in income levels and quality indicators that may relate to the inventors' home country, year in which the invention underlying the questionnaire was developed, and technological sector, using dummy variables for the inventors' home countries (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Great Britain, Greece, Hungary, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, Norway, Poland, Slovenia, Spain, Sweden, Switzerland, or United States), 30 OST-INIPI-ISI[8] technological classes (OECD 1994), and inventions' priority years (2003, 2004, 2005), respectively.

4. OLS Regressions

In addition to exploring whether differences in income and inventive performance exist between female and male inventors, we test whether they persist after we control for several sources of heterogeneity. Table 2 contains the results of five OLS regressions, using gross annual income as the dependent variable. Table 3 reports the results of four OLS regressions using different measures of invention quality: total number of five-year citations, number of five-year citations per inventor, inventive step, and family size. All (nondummy and nonshare) variables are in logarithmic scales.

Models (1)–(5) in Table 2 provide the estimates for inventors' income. In addition to inventors' gender, the first model controls for variables that reflect demographic, supply-side, and employer characteristics. The second model adds controls for task motivation and risk preferences, and the third model includes variables for the tasks andtype of jobs held by the inventor in

[7] However, 8% of inventors did not indicate the size of the project, 0.5% excluded the size of the organization, 28% did not report the number of R&D employees, and 3% did not reveal their department. To avoid losing these observations, we employed a procedure proposed by Hall and Ziedonis (2001) and set the missing values to equal 0, and then added dummy variables to the regression that took a value of 1 in the case of missing values.

[8] Observatoire des Sciences et Technologies, Institut National de la Propriété Intellectuelle and the Fraunhofer Institute for System and Innovation Research.

Table 2 Inventors' Income (OLS)

	(1)	(2)	(3)	(4)	(5)
			INCOME (log)		
FEMALE (dummy)	−0.164*** [0.026]	−0.154*** [0.026]	−0.134*** [0.026]	−0.126*** [0.026]	−0.088** [0.036]
NUMBER OF CHILDREN (log)	—	—	—	0.032*** [0.009]	0.034*** [0.009]
FEMALE × *NUMBER OF CHILDREN* (log)	—	—	—	—	−0.077 [0.048]
MARRIAGE (COHABITING) (dummy)	—	—	—	0.079*** [0.014]	0.079*** [0.014]
WORKING HOURS (log)	0.031*** [0.008]	0.029*** [0.008]	0.023*** [0.008]	0.023*** [0.008]	0.023*** [0.008]
HOURS LEISURE TIME (log)	−0.001 [0.007]	−0.0001 [0.007]	0.010 [0.006]	0.016** [0.007]	0.016** [0.007]
AGE (log)	9.881*** [0.708]	10.010*** [0.706]	8.516*** [0.706]	7.541*** [0.719]	7.623*** [0.718]
AGE SQUARED (log)	−1.227*** [0.095]	−1.245*** [0.095]	−1.058*** [0.095]	−0.936*** [0.096]	−0.946*** [0.096]
HIGH SCHOOL (dummy)	0.162*** [0.040]	0.162*** [0.040]	0.144*** [0.039]	0.141*** [0.039]	0.142*** [0.039]
BACHELOR OR MASTER (dummy)	0.304*** [0.037]	0.303*** [0.036]	0.267*** [0.036]	0.267*** [0.036]	0.267*** [0.036]
PHD (dummy)	0.394*** [0.037]	0.393*** [0.037]	0.350*** [0.036]	0.349*** [0.036]	0.350*** [0.036]
EXPERIENCE (log)	0.058 [0.037]	0.062* [0.037]	0.083** [0.036]	0.081** [0.036]	0.080** [0.036]
EXPERIENCE SQUARED (log)	0.002 [0.008]	0.001 [0.008]	−0.006 [0.008]	−0.007 [0.008]	−0.006 [0.008]
PAST PRODUCTIVITY ADJUSTED (log)	0.045*** [0.004]	0.045*** [0.004]	0.041*** [0.004]	0.041*** [0.004]	0.041*** [0.004]
PAST MOBILITY (dummy)	−0.005 [0.010]	−0.007 [0.010]	0.001 [0.009]	0.002 [0.009]	0.001 [0.009]
FIRM SIZE—MEDIUM SIZED FIRM (dummy)	0.087*** [0.024]	0.090*** [0.023]	0.076*** [0.022]	0.078*** [0.022]	0.079*** [0.022]
FIRM SIZE—LARGE FIRM (dummy)	0.052*** [0.019]	0.059*** [0.019]	0.061*** [0.018]	0.060*** [0.018]	0.060*** [0.018]
RD EMPLOYEES	0.015*** [0.002]	0.016*** [0.002]	0.016*** [0.002]	0.015*** [0.002]	0.015*** [0.002]
RD EMPLOYEES MISSING (dummy)	0.035** [0.015]	0.042*** [0.015]	0.055*** [0.015]	0.057*** [0.015]	0.058*** [0.015]
PUBLIC RESEARCH ORGANIZATION (dummy)	−0.204*** [0.022]	−0.204*** [0.022]	−0.200*** [0.022]	−0.196*** [0.022]	−0.197*** [0.022]
ADVANCEMENT REWARD (log)	—	−0.021*** [0.008]	−0.017** [0.008]	−0.018** [0.008]	−0.018** [0.008]
INDEPENDENCE REWARD (log)	—	−0.034*** [0.008]	−0.017** [0.008]	−0.016** [0.008]	−0.016** [0.008]
SOCIETY REWARD (log)	—	−0.005 [0.008]	−0.009 [0.008]	−0.010 [0.008]	−0.010 [0.008]
RISK ATTITUDE (log)	—	0.084*** [0.011]	0.047*** [0.011]	0.046*** [0.011]	0.046*** [0.011]
TIME DEVOTED TO INVENT (share)	—	—	−0.001*** [0.000]	−0.001*** [0.000]	−0.001*** [0.000]
TIME ROUTINE TASKS (share)	—	—	−0.0002 [0.0002]	−0.0002 [0.0002]	−0.0002 [0.0002]
LEADER (log)	—	—	0.074*** [0.004]	0.071*** [0.004]	0.071*** [0.004]
WORK IN R&D DPT (dummy)	—	—	−0.022 [0.016]	−0.021 [0.015]	−0.021 [0.015]
TOP MANAGEMENT POSITION (dummy)	—	—	0.083*** [0.026]	0.084*** [0.026]	0.083*** [0.026]
Priority years	Included	Included	Included	Included	Included
Tech areas	Included	Included	Included	Included	Included
Countries	Included	Included	Included	Included	Included
Constant	−9.546*** [1.296]	−9.885*** [1.294]	−6.877*** [1.297]	−5.043*** [1.320]	−5.200*** [1.319]
Observations	9,692	9,692	9,692	9,692	9,692
R-squared	0.434	0.439	0.473	0.477	0.477
F	91.63	89.09	99.84	99.55	99.16

Note. Robust standard errors are in brackets.
$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

the organization. Models (4) and (5) add the number of children and the interaction term between the female dummy and the number of children.[9]

In model (1), the *FEMALE* dummy is negative and statistically significant at 1%; being a female inventor is associated with a 16.4% lower salary than being a male inventor, other things being equal. The control variables exhibit the expected signs.[10] Age has a curvilinear relationship with income, with a peak at 56 years. Education positively correlates with income, and a doctoral degree is associated with the largest (39%) increase in salary (with secondary school and vocational training as the reference group). The inclusion of education does not eliminate the negative and statistically significant sign of the gender dummy though. Investments in human capital thus cannot fully capture differences in income. The gender wage gap also resists controls for the number of hours worked, hours dedicated to leisure time, and differences in past productivity and experience; we also included the latter in a quadratic form to account for possible nonlinear relationships with income. In line with existing literature (e.g., Oi and Idson 1999), we find that inventors in medium sized and large firms earn higher incomes than those working for small firms. Specifically, inventors employed by medium-sized firms have an income that is 9% higher than inventors employed with small firms; those in large firms have a 5% higher income. Working for a public research organization is associated with a considerably lower income, such that inventors employed by these organizations are characterized by a 20% lower income than inventors employed with private firms, publicly traded organizations, foundations, or hospitals. The gender-based income gap persists after we control for the type of employer, its size, and R&D employees.

In the second model, we add motivations and risk attitudes. Inventors' motivations to invent reveal a small, negative correlation with income; risk lovers earn higher incomes. Similarly, selection into the types of jobs or tasks (model (3)) matters but does not completely eliminate the gender gap. Being in a managerial position (top or middle management) correlates positively with income (increase by 8%), but devoting more time to R&D shows a negative, though small, correlation. Increasing the number of employees reporting to the inventor (*LEADER*) by 100% would increase income by 7.4%. All other variables remain largely unchanged, compared with models (1) and (2).

Model (4) reveals that being married or having children is positively correlated with income; one more child is associated with a 3.2% higher income. Model (5) adds the interaction term *FEMALE* × *NUMBER OF CHILDREN*, which produces an estimated coefficient that is negative but statistically not significant at standard levels. The latter result, however, must be interpreted with caution: Because of the small number of female inventors (and women with children) in our sample, the interaction term is likely to be imprecisely estimated.

The income gap for female inventors decreases as we move from model (1) to model (5): It is 16.4% when we control only for human capital endowments and employer characteristics, but falls to 15.4% if we add motivations and risk attitude, and then to 13.4% with tasks and jobs characteristics controlled. Adding children and marital status decreases the gap to 12.6%, and finally, the inclusion of the interaction between gender and number of children leaves a gender-based income gap of 8.8%.[11] The goodness-of-fit statistics indicate that controlling for task and job selection produces the largest increase in the R-square value.

Models (1)–(4) in Table 3 provide the estimates for invention quality. We control for the resources invested in the R&D project, in addition to the variables from model (5) in Table 2. Model (1) uses the number of citations received within a five-year window after publication of the patent as a dependent variable. Model (2) uses inventive step. Model (3) exhibits a variation of model (1) that employs fractional citation counts to account for the number of inventors on the inventor team (Narin and Breitzman 1995).[12] Model (4) employs the size of the patent family as a dependent variable. The estimated results indicate that gender does not correlate significantly with income at standard levels. Although women earn less than men, the quality of the inventions they produce does not exhibit a lower value for any of the proxies employed, and neither does the combined effect of gender with children. Regarding the other covariates, we note a few differences across equations, with some variables being statistically significant only for one or few quality indicators; that is, the

[9] These specifications provide "average effects" for all covariates. For the number of children, specification (5) includes an interaction term with gender. The low number of female inventors in our sample prevents us from including interaction terms between all (or several) control variables and gender. To check for gender differential estimates, we reproduced the regressions in Table 2 on the two separate subsamples of male and female inventors (the results are in the electronic companion, §EC.5) and performed the Oaxaca–Blinder decomposition that we report in §7 of this paper for the "endowments" and "coefficients" effects.

[10] We obtained similar signs and significance for the coefficients from a right-censored Tobit regression that we performed because the income variable is censored at 100,000€. The results did not change when we added a measure of the economic value of the invention to model (5), as we show in the electronic companion (§EC.8).

[11] We also estimated the income regressions for different subsamples of inventors grouped according to the number of children that they have. The negative and statistically significant coefficient (10% level) of the female dummy remains for all subsamples, though the magnitude increases with the number of children. The electronic companion (§EC.11) shows the estimated results.

[12] The distribution of the fractional citation count variable is shown in the electronic companion (§EC.6).

Table 3 Forward Citations, Inventive Step, and Family Size (OLS)

	(1)	(2)	(3)	(4)
	# FORWARD CITATIONS (log)	*INVENTIVE STEP* (log)	*# FORWARD CITATIONS/ # OF INVENTORS* (log)	*FAMILY SIZE* (log)
FEMALE (dummy)	−0.046 [0.048]	0.010 [0.023]	−0.037 [0.029]	0.027 [0.055]
NUMBER OF CHILDREN (log)	0.002 [0.014]	−0.015** [0.007]	−0.003 [0.010]	0.027 [0.019]
FEMALE × *NUMBER OF CHILDREN* (log)	0.078 [0.063]	0.006 [0.030]	0.056 [0.041]	−0.089 [0.069]
MARRIAGE (COHABITING) (dummy)	−0.014 [0.020]	0.012 [0.010]	−0.004 [0.014]	0.033 [0.026]
WORKING HOURS (log)	0.013 [0.011]	−0.0005 [0.006]	0.009 [0.007]	−0.005 [0.014]
HOURS LEISURE TIME (log)	−0.005 [0.009]	−0.013*** [0.005]	−0.005 [0.006]	−0.014 [0.011]
AGE (log)	1.335* [0.802]	0.166 [0.426]	0.778 [0.577]	0.799 [1.077]
AGE SQUARED (log)	−0.194* [0.108]	−0.014 [0.057]	−0.109 [0.078]	−0.117 [0.145]
HIGH SCHOOL (dummy)	−0.013 [0.039]	−0.050** [0.022]	−0.020 [0.031]	0.089 [0.066]
BACHELOR OR MASTER (dummy)	−0.017 [0.035]	−0.057*** [0.020]	−0.025 [0.028]	0.087 [0.061]
PHD (dummy)	0.030 [0.037]	−0.040* [0.021]	−0.004 [0.029]	0.096 [0.063]
EXPERIENCE (log)	−0.015 [0.037]	−0.014 [0.021]	−0.001 [0.027]	−0.040 [0.051]
EXPERIENCE SQUARED (log)	0.008 [0.009]	0.010* [0.005]	0.004 [0.007]	0.006 [0.012]
PAST PRODUCTIVITY ADJUSTED (log)	0.026*** [0.006]	0.019*** [0.003]	0.018*** [0.004]	0.001 [0.007]
PAST MOBILITY (dummy)	0.005 [0.014]	−0.008 [0.007]	−0.002 [0.010]	0.010 [0.019]
FIRM SIZE—MEDIUM SIZED FIRM (dummy)	−0.037 [0.029]	−0.021 [0.015]	−0.028 [0.021]	−0.079* [0.042]
FIRM SIZE—LARGE FIRM (dummy)	−0.025 [0.022]	−0.031*** [0.012]	−0.022 [0.016]	−0.102*** [0.030]
RD EMPLOYEES	0.010*** [0.004]	−0.002 [0.002]	0.002 [0.003]	−0.007 [0.005]
RD EMPLOYEES MISSING (dummy)	0.037* [0.022]	−0.019 [0.012]	0.002 [0.016]	−0.068** [0.029]
PUBLIC RESEARCH ORGANIZATION (dummy)	−0.042 [0.028]	0.087*** [0.014]	−0.018 [0.019]	0.006 [0.035]
ADVANCEMENT REWARD (log)	−0.003 [0.011]	0.001 [0.006]	−0.008 [0.008]	−0.003 [0.015]
INDEPENDENCE REWARD (log)	0.008 [0.012]	0.028*** [0.006]	0.006 [0.008]	−0.009 [0.015]
SOCIETY REWARD (log)	0.023* [0.012]	0.048*** [0.006]	0.014* [0.008]	0.027* [0.016]
RISK ATTITUDE (log)	0.004 [0.015]	0.075*** [0.009]	0.013 [0.010]	0.048** [0.020]
TIME DEVOTED TO INVENT (share)	0.0001 [0.0002]	0.001*** [0.000]	0.0002 [0.0002]	0.001*** [0.000]
TIME ROUTINE TASKS (share)	0.0001 [0.0002]	−0.0004** [0.0001]	0.0001 [0.0001]	0.001** [0.000]
LEADER (log)	−0.001 [0.006]	−0.0001 [0.003]	−0.005 [0.004]	−0.001 [0.008]
WORK IN R&D DPT (dummy)	−0.011 [0.020]	−0.032*** [0.011]	−0.019 [0.015]	−0.033 [0.028]
TOP MANAGEMENT POSITION (dummy)	−0.030 [0.031]	−0.006 [0.016]	−0.009 [0.024]	0.075* [0.042]
NUMBER OF INVENTORS (log)	0.111*** [0.011]	−0.016*** [0.006]	—	0.083*** [0.014]
PROJECT SIZE (log)	0.002 [0.006]	0.033*** [0.003]	−0.013*** [0.004]	0.041*** [0.007]
PROJECT SIZE MISSING (dummy)	0.052* [0.028]	0.048*** [0.015]	−0.026 [0.019]	0.121*** [0.033]
Priority years	Included	Included	Included	Included
Tech areas	Included	Included	Included	Included
Countries	Included	Included	Included	Included
Constant	−1.950 [1.479]	0.575 [0.789]	−1.024 [1.059]	1.345 [1.982]
Observations	9,692	9,198	9,692	9,692
R-squared	0.075	0.116	0.034	0.169
F	8.257	12.00	3.672	33.18

Note. Robust standard errors are in brackets.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

four dependent variables measure different aspects of patent quality.

The regressions in Table 3 include a measure of the number of inventors taking part in the research project, to account for teamwork (Singh and Fleming 2010) and for the fact that the merits of the invention should be shared among team members. We try to address individual contributions (and relative merits) further, to investigate whether a gender gap emerges for invention quality conditional on the surveyed inventor having contributed extensively to it. For this purpose, we use the *MY IDEA* variable, which indicates whether the idea underlying the invention originated from the surveyed inventor. In addition, we exploit single inventor patents, as reported in the PATSTAT database.

If women earn a lower income than men because of their lower inventive performance, then ideas that originate from women should produce lower quality inventions, which would justify differences in income. Models (1)–(4) in panel (a) of Table 4 include *MY IDEA* (dummy variable) in addition to the number of inventors in the team. Even after controlling for the surveyed

Table 4 **Forward Citations, Inventive Step, and Family Size, Accounting for Coinventors and Origin of the Idea (OLS)**

	(1)	(2)	(3)	(4)
	# FORWARD CITATIONS (log)	*INVENTIVE STEP* (log)	*# FORWARD CITATIONS/ # OF INVENTORS* (log)	*FAMILY SIZE* (log)
		(a) *MY IDEA* added		
FEMALE (dummy)	−0.045	0.013	−0.027	0.029
	[0.048]	[0.024]	[0.029]	[0.054]
NUMBER OF CHILDREN (log)	0.002	−0.014*	−0.002	0.027
	[0.014]	[0.007]	[0.010]	[0.019]
FEMALE × *NUMBER OF CHILDREN* (log)	0.078	0.007	0.053	−0.089
	[0.063]	[0.030]	[0.040]	[0.069]
NUMBER OF INVENTORS (log)	0.113***	−0.001	—	0.092***
	[0.013]	[0.006]		[0.016]
MY IDEA (dummy)	0.004	0.038***	0.082***	0.025
	[0.015]	[0.008]	[0.009]	[0.019]
		(b) *FEMALE* × *MY IDEA added*		
FEMALE (dummy)	−0.050	0.018	−0.037	0.019
	[0.050]	[0.025]	[0.028]	[0.060]
NUMBER OF CHILDREN (log)	0.002	−0.015**	−0.002	0.027
	[0.014]	[0.007]	[0.010]	[0.019]
FEMALE × *NUMBER OF CHILDREN* (log)	0.077	0.008	0.050	−0.092
	[0.063]	[0.030]	[0.041]	[0.069]
NUMBER OF INVENTORS (log)	0.113***	−0.001	—	0.092***
	[0.013]	[0.006]		[0.016]
MY IDEA (dummy)	0.003	0.038***	0.081***	0.024
	[0.015]	[0.008]	[0.009]	[0.019]
FEMALE × *MY IDEA*	0.021	−0.021	0.044	0.047
	[0.075]	[0.034]	[0.056]	[0.081]
		(c) Sample restricted to *MY IDEA* = 1		
FEMALE (dummy)	−0.021	−0.014	−0.014	0.123
	[0.107]	[0.047]	[0.085]	[0.099]
NUMBER OF CHILDREN (log)	−0.019	−0.024**	−0.019	−0.002
	[0.020]	[0.011]	[0.017]	[0.028]
FEMALE × *NUMBER OF CHILDREN* (log)	0.046	0.037	0.058	−0.164
	[0.137]	[0.059]	[0.110]	[0.134]
		(d) Sample restricted to *NUMBER OF INVENTORS* = 1		
FEMALE (dummy)	−0.091	−0.038	−0.091	0.145
	[0.100]	[0.082]	[0.100]	[0.124]
NUMBER OF CHILDREN (log)	−0.033	−0.023*	−0.033	−0.005
	[0.024]	[0.013]	[0.024]	[0.035]
FEMALE × *NUMBER OF CHILDREN* (log)	0.066	0.052	0.066	−0.272*
	[0.131]	[0.087]	[0.131]	[0.161]
In all specifications:				
All individual, project, and firm controls	Included	Included	Included	Included
Priority years	Included	Included	Included	Included
Tech areas	Included	Included	Included	Included
Countries	Included	Included	Included	Included

Notes. The number of observations is 9,692 ($n = 9{,}198$ for *INVENTIVE STEP*) for panels (a) and (b), 4,431 ($n = 4{,}228$ for *INVENTIVE STEP*) for panel (c), and 2,968 ($n = 2{,}827$ for *INVENTIVE STEP*) for panel (d). Robust standard errors are in brackets.

$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

inventor being a major contributor to the invention, we do not find gender differences in any of the four models. Panel (b) adds the interaction term *MY IDEA* × *FEMALE*. The female dummy remains statistically not significant, below standard levels. When the source of the idea is a woman, the resulting invention is not of lower quality compared with when the source of the idea is a man. Models (1)–(4) in panel (c) reflect a subsample of patents for which the surveyed inventor was the idea originator (*MY IDEA* = 1); the female dummy again plays no role. Models (1)–(4) in panel (d) use the subsample of single inventors' patents, created by the surveyed inventor alone. We still do not find any gender difference for any of the quality indicators. Section EC.10 in the electronic companion shows the estimates for the full set of variables employed in the regressions.

5. Parenthood

5.1. Religious Activities During Leisure Time

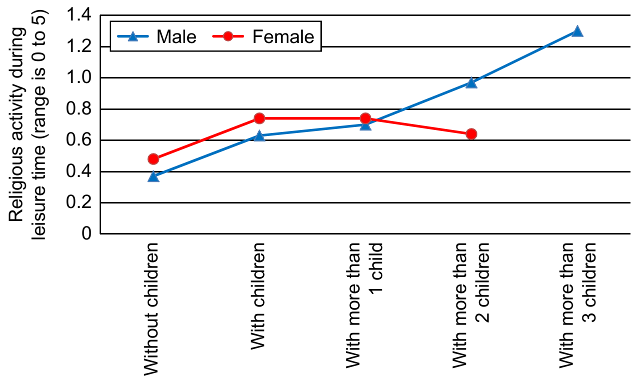
The decision to have children is not exogenous with respect to income. By the 1970s, Waite and Stolzenberg (1976) already had identified two-sided causality between fertility expectations and labor market participation plans. Bloom et al. (2009) use abortion legislation to instrument for fertility and find that legitimate abortion options reduce fertility, whereas each birth reduces labor force participation by approximately two years. Economic research dealing with the relationship between female fertility and wages indicates that when children are exogenous, their effect on labor market outcomes is negative, but this effect decreases in studies that take endogeneity into account (Hill 1979). Finally, sociology research shows that men decide to have children once they earn enough to make their living with a family (Di Stefano and Pinnelli 2004); economic literature confirms this finding (e.g., Butz and Ward 1979). Hence, labor market outcomes and fertility could be jointly determined, with causality running from labor-related indicators to parenthood or vice versa (Korenman and Neumar 1992, Angrist and Evans 1998, Krapf et al. 2014). In addition, though we control for as many observable variables as possible, omitted variables still could affect both income and fertility (e.g., ambitious women decide to have fewer children and earn higher salaries).

Unfortunately, exogenous variations to identify the causal mechanism between family formation and income are difficult to find. Angrist and Evans (1998) use siblings' sex and the occurrence of twins at first birth (see also Bronars and Grogger 1994). Aguero and Marks (2008) and Miller (2011) use measures of biological fertility shocks. We explore the extent to which inventors dedicate time to religious and spiritual activities during their leisure time as an instrument to predict the number of children they potentially have (*RELIGIOUS ACTIVITIES*). Religious beliefs typically develop among and are absorbed by young people prior to their determination of labor market outcomes and parenthood. They are shaped in childhood by parental reinforcement, community memberships, and family and community traditions (Iannaccone 1998, King et al. 2002). Some authors even argue that religiousness has biological roots (Feierman 2009, Rowthorn 2011). In our regressions, we control for the total number of work hours and leisure hours per week and then, given the total leisure time available, derive the religious activities variable from inventors' responses on a Likert scale (1 = never and 6 = very often) to an item about the importance of religious activities among all other activities they could perform during their free time. For religious activities to be a valid instrument, the measure must correlate with the number of children that inventors have but be unrelated with omitted variables that may influence income directly.

We posit that religious activities during leisure time signal social behavior that leads to potentially larger families. Behavioral norms articulated by religion, including rules regulating birth control, contraception, and abortion, tend to lead more religious families to have, on average, more children (Lehrer 1996), though this influence on family planning might have decreased in recent years (Frejka and Westhoff 2008). Religious affiliations also affect marital stability, because people tend to marry partners who share their beliefs and values. Marital stability in turn affects average family size (Iannaccone 1998, Heaton 2011). Hayford and Morgan (2008) show that women who consider religion very important in their lives also express high consideration for marriage and children, which leads to higher fertility intentions. In addition, the level of women's autonomy, which is associated with religious affiliation, correlates with family size (Jejeebhoy 1995, McQuillan 2004). With data from the 2005–2009 wave of the World Value Survey for the countries represented in our INNOS&T survey, we confirm the correlations between religiosity and mechanisms that affect fertility; that is, in countries where religion is more important, a statistically significant lower share of unmarried couples live together (pairwise correlation of 0.61), and higher shares of people declare that homosexuality (0.78), abortion (0.84), and divorce (0.72) are never justifiable. More religious people also assert, more so than less religious people, that it is important that children are encouraged to learn religious faith at home, which confirms the early involvement in religious beliefs.[13] Recent work by Hackett et al. (2015) confirms

[13] On the basis of these data, Inglehart and Welzel (2005) highlight that, compared with people with secular-rational values, people with secular-traditional values rate religion and traditional family values highly but strongly reject divorce, abortion, euthanasia, and suicide.

Figure 8 (Color online) Religious Activities During Leisure Time (0 = Never; 5 = Very Often) and Number of Children ($N = 9{,}692$; Men = 9,283; Women = 409)



that the total fertility rate of women with a religious affiliation is almost one child greater (2.59 versus 1.65 children per woman) than that of religiously unaffiliated women. As Figure 8 shows, *RELIGIOUS ACTIVITIES* correlates with having at least one child and with the number of children that inventors, men and women, had. It also correlates with inventors' personality traits and social behavior, such as spending time to volunteer with social and care services or on family-related activities (these results are available in the electronic companion, §EC.7).

The test of whether the instrument correlates with omitted variables that could influence income is more difficult. We provide arguments in support of the exclusion restriction. Religion could affect income through some activated mechanisms. For example, Guiso et al. (2003) find that religious people trust others, the government, and the legal system more, and they are less willing to break rules. These attitudes may result in self-selections into different (e.g., less competitive) jobs or encourage different (less competitive) behavior at work. Miller and Hoffmann (1995) and Osoba (2003) find a negative relationship between religiosity and willingness to take risks, which may lead to lower wages. We control for selection into different types of jobs and risk-taking behavior, as well as for several other plausible mechanisms that may correlate with religion, such as the number of hours worked or dedicated to leisure time (Heintzman and Mannell 2003), individual motivations and preferences (Stavrova and Siegers 2013), and education (Bressler and Westoff 1963, Lerner 2004). With these controls in place, attachment to religion can be considered an exogenous (i.e., formed early in life, dependent on family traditions and beliefs) source of variation that correlates with the number of children an inventor has.

As further support for these arguments, we estimated the coefficients for *RELIGIOUS ACTIVITIES* from regressions using the items in Table 5 as dependent variables and *RELIGIOUS ACTIVITIES* as the main regressor. In addition, we included *AGE*, *AGE SQUARED*, and time, country, and technology dummies as control variables.[14] With these regressions, we investigate whether people who dedicate their spare time to religious activities differ systematically from those who do not (or who dedicate less time to these activities). The results do not exhibit significant differences for gender, leadership roles, time devoted to routine activities, hours of work and leisure, or any of the variables reflecting inventors' capabilities and abilities (e.g., education, mobility, past productivity, risk attitude). As expected, inventors who are more religious are more likely to be married and have children. They also are motivated by all three reasons we identified for people to conduct research, and they are less likely to work for small firms. This finding suggests that we must control for these variables in the regressions and that possible explanations for income differences that we control for (e.g., education, working hours) do not result from the religious activities variable. In addition, possible omitted variables (in the error term) correlated with education or effort do not correlate with religiosity. In summary, once we take schooling and other inventor-specific variables into account, religious activities during leisure time do not appear to have an independent effect on income. Consistent with Zhang's (Zhang 2008) finding that

Table 5 Inventors' Characteristics by Religious Activities

Variables		
FEMALE	0.020	[0.053]
MARRIAGE (COHABITING)	0.096**	[0.038]
NUMBER OF CHILDREN	0.140***	[0.010]
TIME DEVOTED TO INVENT	−0.531	[0.620]
TIME ROUTINE TASKS	−0.353	[0.540]
LEADER	−0.028	[0.025]
TOP MANAGEMENT POSITION	−0.072	[0.045]
ADVANCEMENT REWARD	0.065***	[0.013]
INDEPENDENCE REWARD	0.038***	[0.013]
SOCIETY REWARD	0.071***	[0.012]
HOURS LEISURE TIME	−0.015	[0.016]
WORKING HOURS	−0.005	[0.011]
EXPERIENCE	−0.026*	[0.014]
FIRM SIZE	0.072***	[0.024]
RD EMPLOYEES	0.127**	[0.061]
PUBLIC RESEARCH ORGANIZATION	−0.053	[0.049]
EDUCATION	−0.015	[0.023]
WORK IN R&D DPT	0.006	[0.033]
PAST MOBILITY	−0.037	[0.029]
RISK ATTITUDE	0.010	[0.009]
PAST PRODUCTIVITY ADJUSTED	0.030	[0.026]

Notes. $N = 9{,}692$. Variables for R&D employees, firm size, and inventors' department exclude missing observations. Robust standard errors are in brackets. All regressions control for *AGE*, *AGE SQUARED*, and country, time, and technological dummies.

$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

[14] We employed OLS regressions with robust standard errors for the continuous variables and probit regressions for the dummy variables.

Table 6 Inventors' Income (2SLS)

	(1)	(2)
	INCOME (log)	
	Second-stage estimates	
FEMALE (dummy)	−0.145*** [0.026]	−0.456* [0.257]
NUMBER OF CHILDREN (log)	−0.152** [0.070]	−0.163** [0.069]
FEMALE × *NUMBER OF CHILDREN* (log)	—	0.623 [0.511]
MARRIAGE (COHABITING) (dummy)	0.164*** [0.036]	0.159*** [0.037]
WORKING HOURS (log)	0.023*** [0.008]	0.023*** [0.008]
HOURS LEISURE TIME (log)	0.006 [0.007]	0.010 [0.008]
AGE (log)	8.940*** [0.894]	8.215*** [1.154]
AGE SQUARED (log)	−1.103*** [0.116]	−1.008*** [0.149]
HIGH SCHOOL (dummy)	0.136*** [0.039]	0.134*** [0.039]
BACHELOR OR MASTER (dummy)	0.258*** [0.036]	0.255*** [0.036]
PHD (dummy)	0.338*** [0.036]	0.331*** [0.037]
EXPERIENCE (log)	0.065* [0.036]	0.072* [0.038]
EXPERIENCE SQUARED (log)	−0.002 [0.008]	−0.004 [0.009]
PAST PRODUCTIVITY ADJUSTED (log)	0.041*** [0.004]	0.040*** [0.004]
PAST MOBILITY (dummy)	−0.001 [0.010]	0.002 [0.010]
FIRM SIZE—MEDIUM SIZED FIRM (dummy)	0.070*** [0.023]	0.068*** [0.023]
FIRM SIZE—LARGE FIRM (dummy)	0.062*** [0.018]	0.061*** [0.019]
RD EMPLOYEES	0.015*** [0.002]	0.015*** [0.002]
RD EMPLOYEES MISSING (dummy)	0.054*** [0.015]	0.051*** [0.016]
PUBLIC RESEARCH ORGANIZATION (dummy)	−0.200*** [0.022]	−0.195*** [0.022]
ADVANCEMENT REWARD (log)	−0.015* [0.008]	−0.015* [0.008]
INDEPENDENCE REWARD (log)	−0.015** [0.008]	−0.016** [0.008]
SOCIETY REWARD (log)	−0.007 [0.008]	−0.006 [0.008]
RISK ATTITUDE (log)	0.046*** [0.011]	0.042*** [0.012]
TIME DEVOTED TO INVENT (share)	−0.001*** [0.000]	−0.001*** [0.000]
TIME ROUTINE TASKS (share)	−0.0002 [0.0002]	−0.0002 [0.0002]
LEADER (log)	0.076*** [0.004]	0.077*** [0.004]
WORK IN R&D DPT (dummy)	−0.028* [0.016]	−0.029* [0.016]
TOP MANAGEMENT POSITION (dummy)	0.081*** [0.026]	0.084*** [0.026]
Priority years	Included	Included
Tech areas	Included	Included
Countries	Included	Included
Constant	−7.809*** [1.689]	−6.416*** [2.194]
Observations	9,692	9,692
R-squared	0.455	0.438
F	95.28	91.65
First-stage estimates of excluded instruments		
LEISURE TIME RELIGIOUS ACTIVITIES (log)	0.131*** [0.010]	0.134*** [0.010]
FEMALE × *LEISURE TIME RELIGIOUS ACTIVITIES* (log)	—	−0.064 [0.039]
F test (of excluded instruments)	188.68***	95.21*** (5.73*** for interaction term)

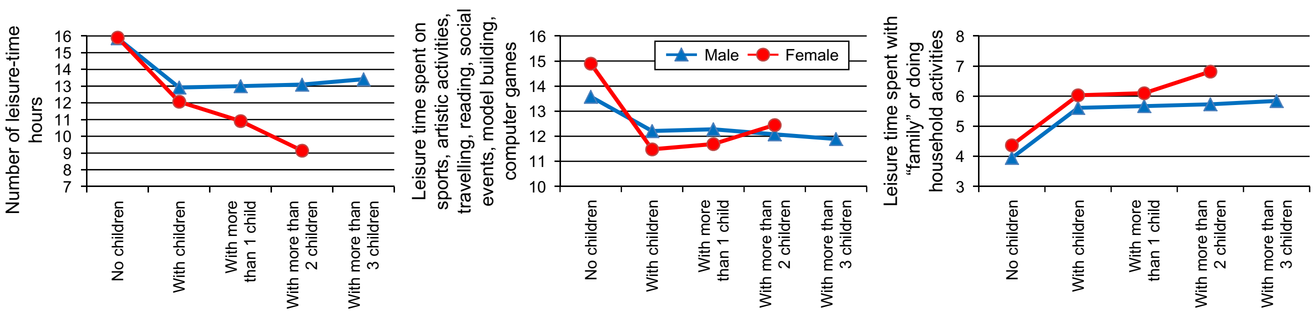
Notes. Robust standard errors are in brackets. In model (1), the Kleibergen–Paap *rk* Wald *F* statistic is 188.68; the Anderson–Rubin test is 4.93**. In model (2) they are 2.61 and 8.36**, respectively.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

religious beliefs affect the fertility of both men and women, we use this information as an instrument for both male and female inventors.

5.2. Results of Instrumental Variable Regressions

Table 6 contains the results of two-stage least squares (2SLS) regressions that use *RELIGIOUS ACTIVITIES* to instrument the potential number of children. Model (1) contains all explanatory and control variables; model (2) adds the interaction term between gender and the number of children. The first-stage estimates in the bottom rows of Table 6 exhibit positive correlations, statistically significant at the 1% level between *RELIGIOUS ACTIVITIES* and the number of children. The reduced form regression shows a negative association between the instruments and the dependent variable (the full set of first-stage estimates is available in the electronic companion, §EC.9). In model (1), the *F*-tests for the excluded instruments and the other first-stage statistics suggest the instrumental variable (IV) has power when we estimate the specification with only children as the endogenous variable. We can reject the null hypothesis of the underidentification test at the 1% level, which indicates the model is identified. The *F*-test remains high in model (2) for the instrumented children. It is lower for the instrumented interaction term. Similarly, the Kleibergen–Paap *rk* statistic is much lower than in model (1). Again, as in the case of the OLS regression, this result likely is due to the relatively few women in our sample, and the even smaller number

Figure 9 (Color online) Leisure Time Activities by Gender and Number of Children ($N = 9{,}692$; Men = 9,283; Women = 409)



of women with children (especially more than one child). In addition, as also argued by Bun and Harrison (2014), the nonlinearity of the model that employs the interaction between the instrument and the exogenous part of the interaction term to identify the latter leads to underidentification, irrespective of the strength of the instruments.

The female dummy in model (1) retains a negative sign and is statistically significant at the 1% level. The magnitude of the coefficient (14.5%) is in line with that estimated in the OLS regressions (12.6%). The signs, magnitudes, and statistical significance of the control variables remain largely unchanged compared to the OLS regressions (model (4) in Table 2).

However, whereas the OLS regression in Table 2 indicated a positive, statistically significant coefficient of children on income (1% level), the corresponding IV estimates reveal a negative, statistically significant coefficient (5% level) on both men's and women's incomes. Specifically, having one more child is associated with a decrease in income by 15.2%. This result suggests that the OLS coefficient for children was overestimated, consistent with the notion that parents establish families and have children when they can undertake the associated responsibilities and afford the costs. This association produces the positive relationship between the number of children and income in the OLS regressions. When the IV regressions account for this possibility, the negative association of children with both male and female income suggests that parents in these highly skilled jobs share the workload for raising children, such that men take on family commitments and pay the price, namely, a relatively lower income than peers with no children.

Figure 9 supports this interpretation: The number of weekly hours dedicated to leisure is smaller for both female and male inventors who have children (first panel). Meanwhile, given the total amount of leisure time they enjoy, parents rate hobby-like activities (e.g., sports, art, travelling, reading, socializing, computer games, model building; second panel) as less important, whereas spending time with family and household maintenance are rated as more important (third panel), than do inventors without children. Model (2) in Table 6 also indicates a statistically nonsignificant interaction term between gender and children. However, this result must be interpreted with caution, because the instrument may not well identify the coefficient of the potentially endogenous interaction term. The negative and statistically significant coefficient of the female dummy, however, remains.[15]

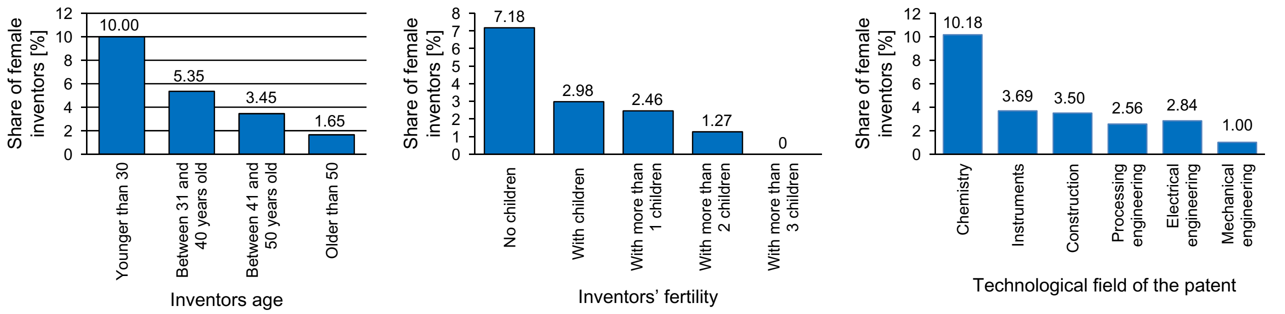
6. Women's Self-Selection

As we discussed previously, we observe a positive selection of female employees into inventive professions. Dealing with women's self-selection, however, would require information about the population of women who might enter these jobs (Heckman 1979). Unfortunately, we only observe women who already had entered and survived in inventive jobs. To overcome this limitation, we turn to other sources of information, including scientific literature and reports, to explicate the possible selection processes at different stages (Leszczensky et al. 2013). We also provide a robustness check to rule out selection as an explanation for our results: We employ propensity score matching and compare men and women paired along several dimensions that likely affect selection, such as age, level of education, technological field of activity, home country, and priority year of the patent.

As Table 1 confirms, women in our sample differ systematically from their male peers. On average, they are five years younger than men and thus have less experience, fewer children, and a lower probability of being married. Compared with male inventors, much higher shares of female inventors have earned doctoral

[15] As an alternative procedure to the instrumental variable approach in model (2.1) that uses the interaction between the instrument and the female dummy in the first stage to identify the interaction term, we follow a recent contribution by Bun and Harrison (2014) and do not instrument the interaction term. The results indicate that the coefficient of the female dummy variable is -0.156^{***}; the instrumented number of children is -0.152^{**}. The interaction term is positive (0.022) and statistically not significant. Finally, we estimate separate regressions for the two subsamples of male and female inventors. The results remain robust for male inventors (negative, statistically significant coefficient of children), but as we suspected, weak identification arises for the female subsample. The results are displayed in the electronic companion (§EC.5).

Figure 10 (Color online) Share of Female Inventors by Age Class, Fertility, and Technological Field of Patent ($N = 9{,}692$; Men = 9,283; Women = 409)



degrees, work in public research organizations, and devote more time to R&D and nonroutine activities than men. Thus, female inventors are more highly qualified than male inventors, after controlling for observable characteristics.

Figure 10 depicts the type of selection processes that women exhibit toward inventive jobs. The share of women in the sample decreases, moving from younger to older age classes, such that it reaches 10.0% for inventors under 30 years of age, and then decreases to 5.4% for the 31–40 age category, 3.5% for 41–50 years, and 1.7% for the over-50 years age category. Either the dropout rate is very high for women over 30 years or more women have chosen to become inventors in recent decades. The second panel of Figure 10 also shows that the share of women is higher among inventors without children and decreases as the number of children increases. The fertility profile of female inventors is consistent with their age distribution, as well as with the theory of dropout due to motherhood.

The third panel of Figure 10 shows that the share of women is higher in chemical industries (10.2%), but drops to about 3.7% for instruments, 3.5% for construction, and 1% for mechanical engineering. Unreported results confirm that female inventors enroll more frequently in fields of study such as biology (17.5% of inventors in this field), health (10.4%), and education (9.7%). In engineering, women represent only 1.8% of the inventors. These differences suggest that women's selection occurs before their entry into the workforce, and it depends on their degree field. In particular, few women graduate in engineering disciplines, which limits their presence in this profession.

Because female and male inventors can be differently selected into this profession, we checked our results on a sample of inventors, constructed using a propensity score matching method to match male and female inventors on relevant selection variables: age, level of education, technical field of activity, year of patent filing, and country. We matched the 409 women in our sample with 409 similar male inventors along these variables, leading to a total sample of 818 inventors. The estimated results of the regressions performed on this sample are displayed in Tables 7 and 8. The complete set of results and the first-stage regressions are displayed in the electronic companion (§EC.10). The coefficient of children in Table 7 is negative already in the OLS regressions, suggesting that matching may have equaled out the differences between male and female inventors. Because of the small sample size and the large number of control variables included in the specifications, the statistical power of these estimations is lower than that of the regressions that employed the full sample of observations. The female dummy remains negative and statistically significant at the 1% or 5% level in specifications (1) and (1.1). The lack of power can explain why, when we add the interaction term between gender and number of children (models (2) and (1.2)), the gender dummy is no longer significant at the 10% level. Table 8 shows the estimated results of matched sample regressions explaining inventive performance. Again, the results remain robust; we do not find gender differences in the quality of the inventions.

7. Oaxaca–Blinder Decomposition

We performed the Oaxaca–Blinder decomposition to understand what portion of the gender gap in income can be attributed to differences in the characteristics of women and men, as well as what portion remains unexplained. For the full specification OLS model and IV regression, which predicts the number of children using inventors' involvement in religious activities, Table 9 confirms that male and female inventors earn different incomes. This table also reports the detailed decomposition for variables that are statistically significant for the explained or unexplained portion of the gap. The upper panel of Table 9 contains the mean predictions of the log of income by groups and their difference, which amounts to 0.335; transforming the variable into its original scale, we obtain a difference of 39.8%. The lower part of Table 9 divides the gender gap into three parts: the mean increase in women's income if they had the same characteristics (endowments) as men, the change in women's income if men's coefficients were applied to women's characteristics,

Table 7 Matched Samples: Income (OLS and 2SLS)

	(1)	(2)	(1.1)	(1.2)
	INCOME (log)		*INCOME* (log)	
	OLS regressions		IV regressions—Second-stage estimates	
FEMALE (dummy)	−0.090***	−0.043	−0.084**	−0.093
	[0.033]	[0.049]	[0.038]	[0.234]
NUMBER OF CHILDREN (log)	−0.052	−0.013	−0.006	−0.011
	[0.039]	[0.044]	[0.221]	[0.171]
FEMALE × *NUMBER OF CHILDREN* (log)	—	−0.085	—	0.016
		[0.064]		[0.460]
All individual and firm controls	Included	Included	Included	Included
Priority years	Included	Included	Included	Included
Tech areas	Included	Included	Included	Included
Countries	Included	Included	Included	Included
Constant	−12.821**	−12.816**	−11.680	−11.610
	[5.562]	[5.560]	[8.025]	[9.157]
Observations	818	818	818	818
R-squared	0.600	0.601	0.599	0.599
F	—	—	91.59	90.27
First-stage estimates of excluded instruments				
LEISURE TIME RELIGIOUS ACTIVITIES (log)	—	—	0.153***	0.233***
			[0.030]	[0.042]
FEMALE × *LEISURE TIME RELIGIOUS ACTIVITIES* (log)	—	—	—	−0.155***
				[0.058]
F test (of excluded instruments)	—	—	25.50***	16.77*** (3.26** for interaction term)

Note. Robust standard errors are in brackets. In model (1.1), the Kleibergen–Paap *rk* Wald *F* statistic is 25.50; the Anderson–Rubin test is 0.00. In model (1.2) they are 2.77 and 0.01, respectively.
**$p < 0.05$; ***$p < 0.01$.

Table 8 Matched Samples: Forward Citations, Inventive Step, and Family Size (OLS)

	(1)	(2)	(3)	(4)
	# FORWARD CITATIONS (log)	*INVENTIVE STEP* (log)	*# FORWARD CITATIONS/ # OF INVENTORS*	*FAMILY SIZE* (log)
FEMALE (dummy)	−0.068	0.063*	−0.033	0.031
	[0.072]	[0.036]	[0.044]	[0.073]
NUMBER OF CHILDREN (log)	−0.053	0.021	−0.066	0.064
	[0.068]	[0.035]	[0.044]	[0.074]
FEMALE × *NUMBER OF CHILDREN* (log)	0.105	−0.023	0.065	−0.059
	[0.088]	[0.046]	[0.055]	[0.091]
All individual, project, and firm controls	Included	Included	Included	Included
Priority years	Included	Included	Included	Included
Tech areas	Included	Included	Included	Included
Countries	Included	Included	Included	Included
Constant	−10.001	0.180	−4.559	1.516
	[6.620]	[3.532]	[4.019]	[7.232]
Observations	818	746	818	818
R-squared	0.145	0.214	0.175	0.260

Note. Robust standard errors are in brackets.
*$p < 0.10$.

and the simultaneous effect of differences in both coefficients and characteristics.[16] The endowments account for 0.190 (statistically significant, 1% level) of the gap in the OLS regressions, indicating that more than half of the income gap can be explained by differences in endowments. In particular, if we could "adjust" women's endowment levels to match those of men, women's income would increase by 20.9% (18.2% in the IV model). Differences in age, time devoted to R&D, leadership roles, and being employed in a public

[16] The detailed decomposition employs a transformed education dummy variable (with the option "categorical"), such that the results are invariant to the choice of the base category. The percentage of the explained gap reflects the threefold decomposition. The overall percentage of the unexplained gap is estimated from a twofold decomposition followed by the option "eform."

Table 9 Decomposition Results

Differential		
Prediction male	10.950*** [0.005]	
Prediction female	10.615*** [0.034]	
Difference	0.335*** [0.035]	
Specifications in Table 3	Explained	Unexplained
Specification (1)	0.171***	0.164***
Specification (2)	0.181***	0.154***
Specification (3)	0.201***	0.134***
Specification (4)	0.209***	0.126***
Specification (4)	OLS regressions	IV regressions
Endowments	0.190*** [0.044]	0.167** [0.077]
NUMBER OF CHILDREN (log)	−0.052*** [0.020]	−0.131 [0.209]
TIME DEVOTED TO INVENT (share)	0.038*** [0.013]	0.035** [0.015]
LEADER (log)	0.035*** [0.012]	0.035*** [0.013]
AGE (log)	1.765*** [0.646]	2.242* [1.349]
AGE SQUARED (log)	−1.646*** [0.650]	−2.089* [1.270]
PUBLIC RESEARCH ORGANIZATION (dummy)	0.028*** [0.010]	0.030*** [0.010]
RISK ATTITUDE (log)	0.012* [0.007]	0.014 [0.009]
Coefficients	0.127*** [0.029]	0.148*** [0.028]
NUMBER OF CHILDREN (log)	0.105*** [0.033]	0.138 [0.347]
PAST MOBILITY (dummy)	0.043** [0.022]	0.046** [0.022]
PUBLIC RESEARCH ORGANIZATION (dummy)	0.025* [0.014]	0.028** [0.014]
HOURS LEISURE TIME (log)	−0.136* [0.080]	−0.079 [0.228]
Interaction	0.017 [0.038]	0.020 [0.074]

Note. $N = 9{,}692$. Standard errors are in brackets.
$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

research organization are the most relevant contributors to the explained portion of the gap. Children (with a negative sign) are statistically significant at the 1% level only in the OLS model, not in the IV regression. Overall, though, 13.4% of the income gap remains unexplained by differences in the observable characteristics included in the models.

8. Conclusions and Limitations

Using information about 9,692 inventions and inventors worldwide, this study confirms a gender-based income gap in favor of male inventors. This gap does not correspond to better inventive performance, in terms of the technological or market quality of the inventions produced. This finding is surprising; we would have expected wages to compensate for differences in performance in these knowledge-intensive jobs, based on education and technological skills, in which workers' productivity can be largely observed. Whereas labor market literature typically relies on wage data to infer productivity (e.g., Topel and Ward 1992), and thus makes it difficult to separate out productivity and wage gaps, we employed measures of individual inventive performance, determined by the quality of the inventions. We find that female inventors perform as well as men in terms of producing high-quality patents. These results hold even after we control for the contribution of female inventors to the invention. Nevertheless, the income of female inventors is lower than that of male inventors.

This income gap cannot be explained fully by differences in the inventors' observable characteristics (e.g., working hours, past productivity levels, education, selection into different jobs, type of employer). Comparing the explanatory power of the different potential determinants of the gap, we find that task and job selection (work in the R&D department, time devoted to invention or routine tasks, personnel or managerial responsibility) are strong predictors of income differentials.

The gender-based income gap also remains after we control for the potential endogeneity of fertility. The coefficient of children is positive in OLS regressions, but negative in the IV regressions for both female and male inventors' income. The overestimation of the children variable in the OLS regression is consistent with the idea that inventors have children when they can afford to do so, and the IV results suggest that in this profession, men and women share the burden of raising children, which can lead them to select family-friendly jobs, such as those that require less extensive travel.

Beyond the large, partly unexplained income gap, we identify the extremely small share of women in this profession (4%); those that access and survive have different characteristics than male inventors. Women's access and retention in inventive professions appear influenced by a positive selection by particularly able women. More worrisome, female inventors tend to be younger, single, and with fewer children than men, which may point to a form of income penalty that is not fully manifested by income differences, because we only observe those who survive in this profession. Using propensity score matching, we try to achieve equivalence in obvious sources of selection, such as level of education, age, or technical fields of activity. Women continue to earn less than men, but we cannot fully rule out the idea that different selections would lead to even larger income gaps between male and female inventors.

In addition, the share of women amounts to only 4%, which points to a clear inefficiency. If talent is equally distributed between genders, there is an overreliance on men's and an underexploitation of women's potential. Moreover, obstacles to women's participation are more punitive in highly skilled and creative jobs, in which many workers enjoy working and are willing to give up their leisure time for "leisure work" (*The Economist* 2014).

We acknowledge some limitations of our study. First, we find that family size does not affect women more than men, but this result should be taken with some caution. Although we instrumented potential parenthood and sought to control for selection with propensity score matching, the relatively few women in our sample, coupled with the possibility that women with children are underrepresented among the wider category of employed women, challenges the estimation of the interaction term between gender and number of children. Second, because our study is based on cross-sectional data, we cannot control for individual, unobserved characteristics with inventors' fixed effects. Gender, our key variable, is not time variant, so fixed effects would elide it. We adopted an IV approach in an effort to mitigate this concern. Third, our data came from a survey of inventors with at least one patent, such that we excluded inventors who have never produced a patented invention, which might have led to a selection bias in favor of more productive or talented inventors. This bias would not create concerns if men and women were not affected differently by the exclusion, particularly if it increased the share of "more talented" women in our sample; that is, a bias that favors the inclusion of better female than male inventors (i.e., toward the selection of top women inventors), which the descriptive statistics show, would lead to an underestimation of the gap we identify, consistent with the idea that more talented women resist the job. In this case, we would be estimating a lower bound effect.

These issues might be addressed by further research. For example, by linking patent data to tax records, researchers could control for people's self-selection into inventive jobs, as some studies recently have started to do for inventors' life cycles.[17] Additional studies could combine employer–employee linked data (e.g., social security data) with patent and survey data. Survey information could provide detailed insights into employee motives, types of tasks, and job performance. Furthermore, the sampling of potential survey respondents could reflect the types of jobs to which employees are assigned or their fields of education. Such data also could help researchers trace inventive activity over time and solve part of the selection problem, in that female inventors who dropped out of R&D would remain observable.

Our results contribute to extant literature by simultaneously comparing differences in wages and productivity for female and male R&D workers. The finding that wages are not fully explained by differences in productivity has powerful implications for firms. In particular, firms may take advantage of this highly skilled (and in R&D-related jobs, so far unexploited) source of human capital, as Siegel et al. (2014) show in their study of multinational firms in South Korea. We also provide a comprehensive analysis of several possible determinants of wage gaps, as well as their predictive power for employees in knowledge-intensive jobs. This research adds to innovation management literature by focusing on the key sources of inventive processes, namely, inventors, and the factors that explain differences in their remuneration. Remuneration is an important reward for employees in industrial R&D; unexplained or seemingly unfair income differences may lead inventors to select out of the profession or to underperform in an inventive job.

Our findings are also important for policy makers. Women are significantly underrepresented among inventors, and those who succeed as inventors earn less than their male peers. Policy makers might intervene to foster greater access to science-based professions during early education. To stimulate science and engineering enrollment by women, teachers might seek to encourage female students to engage in scientific studies; school administrators also could provide information to families about the importance of early (scientific) learning and socialization processes that influence children's preferences for science. In addition to intervening in early educational stages, to equip women with the skills and competences required to pursue inventive jobs, government action is required to create mechanisms for ensuring equal wages for equally performing or skilled employees. One reason for the relatively few women in inventive jobs may be that

[17] Researchers such as Bell et al. (2015) are working on these questions, as the presentations at the National Bureau of Economic Research Summer Institute 2015 reveal (see http://conference.nber.org/confer/2015/SI2015/PRINN/PRINNprg.html, accessed July 14, 2015).

women recognize the lower return they would earn from becoming an inventor. Furthermore, they may anticipate the potentially negative impact of having children, causing them to refrain from choosing careers in R&D or to drop out early. Not only must managers and employees remain aware of this issue, but targeted actions also are required to make compensation equal, such as through investments in affordable, high-quality childcare to help women maintain continuous work histories or legislation that mandates pay transparency.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mnsc.2015.2357.

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