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Scientific Productivity and Gender Performance Under Open and Proprietary Science Systems: The Case of Chile in Recent Years

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SCIENTIFIC PRODUCTIVITY AND GENDER PERFORMANCE UNDER OPEN AND PROPRIETARY SCIENCE SYSTEMS: THE CASE OF CHILE IN RECENT YEARS

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I. INTRODUCTION

Several factors have contributed to the strengthening of Intellectual Property Rights (IPR) protection across the globe. Among them is the belief that stronger IPR protection fosters creativity and the accumulation of knowledge, which most economists agree is the ultimate determinant for long-term economic progress. It is unclear, to date, whether an agreement may be reached regarding the legitimacy of this belief. In contrast, it is

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reasonably well established that the production of knowledge takes place under two different, yet not exclusive, institutional frameworks: *open science* and *proprietary science* institutions.[1] Institutions of open science allow third parties rapid and expeditious access to and use of the knowledge developed by individuals (such as diverse forms of patronage, namely different forms of "subsidies": prizes, rewards, public procurement, etc.), while proprietary institutions enable individuals to establish diverse forms of (tight) control mechanisms of access to knowledge that fall under their control (either resulting from authorship or otherwise). Whereas the former is believed to be responsible for fostering the creation of a large part of extant knowledge, mostly through academic activity, the latter is believed to have been responsible for the emergence of another part of existing knowledge, mostly targeting market-oriented economic activity. In fact, many developed and developing countries have strengthened their IPR as part of their public policy for promoting of science and technology. Strengthening IPR across the globe has raised dual policy concerns: (1) whether countries are succeeding in providing greater incentives for accumulating knowledge, and (2) whether they are reaching a satisfactory balance between providing adequate incentives for creating and accumulating knowledge and the appropriate means for facilitating access thereto. A domain of concern less frequently linked with science and technology policy is the relation between IPR and gender biases in the scientific world. This Article tackles this linkage by focusing on Chile, which is a developing middle-income economy. The Article studies differences in scientific output between genders across institutional frameworks that foster scientific production.

As indicated below, men predominate in the population of scientists

1. For different aspects of the shifting relationship between open and proprietary science institution see Partha Dasgupta & Paul A. David, *Toward a New Economics of Science*, 23 RES. POL'Y 487, 489 (1994) (questioning what creates barriers to the transfer of scientific knowledge and discussing relationships between different remedies for *market failure* in the production of knowledge, namely open and proprietary institutions, at the time of arguing that a reasonably efficient allocation of resources in the production of knowledge requires that modern societies "have both communities firmly in place, and attend to maintaining a synergetic equilibrium between them"); Paul A. David, *The Historical Origins of 'Open Science': An Essay on Patronage, Reputation and Common Agency Contracting in the Scientific Revolution*, 3 CAPITALISM & SOC'Y 1, 9 (2008) [hereinafter David, *Historical Origins*]; Paul A. David, *Tragedy of the Public Knowledge 'Commons'? Global Science, Intellectual Property and the Digital Technology Boomerang* 10 (Maastricht Econ. Research Inst. on Innovation and Tech., Infonomics Research Memorandum Ser. No. 2001-003, 2001), *available at* http://www.merit.unu.edu/publications/ rmpdf/2001/rm2001-003.pdf (arguing that recent developments in intellectual property protection are creating a new and different "tragedy of the commons," or the "destruction of the public knowledge base necessary for scientific and technological research by 'over-fencing'—the erection of artificial barriers whose purpose is the extraction of economic rents").

worldwide and, according to some authors, have outperformed women in scientific output. Within this context, the question is whether the incentive structure for fostering the generation of and access to knowledge is gender neutral. Does scientific production differ between genders across incentive structures? If scientific productivity across incentive systems for producing scientific contributions is not gender biased, then stronger IPR would not alter the relative standing of women in science. However, if the incentive system determines gender differences in scientific output, then stronger IPR might trigger gender policy issues that policy makers have not taken into account until now. Would scientific and technological policy design be the same if incentives derived from proprietary science were less attractive for female scientists than those derived from open science? Some reports from developed countries indicate that female scientific production in "commercial science" is scant compared to academic output. The relevance of these reports for countries with lower levels of development is not yet clear, as few country-level studies examining gender in scientific productivity are available. The more the pattern found in the developed world is systematically evidenced in less developed countries, the more structural the explanatory rationales are likely to be, albeit without identifying the factors triggering such differences. This Article explores the pervasiveness of such patterns of gender productivity differences between open and proprietary science regimes reported for developed countries in Chile, a country with a lower level of economic development. I analyze scientific production through academic publications for the open science system and through patenting activity for the proprietary science system.

This Article is organized into five parts. Part II briefly reviews the literature concerning women in science. Part III discusses the main features of proprietary and open science institutions in their relative ability to foster knowledge accumulation. Part IV exposes some of the main features related to Chile's capacity for generating scientific progress and some gender considerations known to date. Part IV also discloses some findings about gender productivity in science and knowledge creation in different institutional environments and open and proprietary science frameworks. Part V presents the Article's conclusions.

II. WOMEN IN SCIENCE

Several reports reveal that women's participation in scientific production is low, regardless of the degree of economic development of the country analyzed. In developed countries, women dedicated to scientific production do not appear to exceed an average of 25% of scientists.[2] In 1999, the European Union (EU) reported that the proportion of women scientists working in academia, government, and industry did not exceed 25% of researchers.[3] Proportions vary by discipline and country; for example, in 2000, 33% of material science sector researchers in Spain were women,[4] and 23.6% of scientific and engineering positions in the United States were held by women in 1999.[5] Among developed countries, Japan appears to have the lowest level of female participation in science at only 13.9% of academic researchers.[6]

The gender divide grows in the industrial sector and in higher-ranking positions within the research stratum.[7] There is a debate over which factors determine the attrition of women involved in scientific research. Some argue that attrition reflects gender gaps in abilities, such as math, while others believe it reflects gender traps in the scientific world.[8] While many authors have argued that opportunities for women to thrive in science have been more elusive and scarce when compared to those available for men,

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2. *See* NAT'L SCI. BD., SCIENCE AND ENGINEERING INDICATORS 146 (2002) (reporting that, although female participation rates in science and engineering industries in the United States are about half the level reported in labor force, short-term trends indicate an increase in women holding doctorates who are employed in such industries).

3. *See* EUROPEAN COMM'N DIRECTORATE-GENERAL FOR RESEARCH, WOMEN IN INDUSTRIAL RESEARCH ANALYSIS OF STATISTICAL DATA AND GOOD PRACTICES OF COMPANIES 20 (2003) (reporting different female participation rates in the science sector both at industry and government across European countries).

4. *See* Elba Mauleón & María Bordons, *Productivity, Impact and Publication Habits by Gender in the Area of Materials Science*, 66 SCIENTOMETRICS 199, 203 (1992) (reporting a similar proportion in the material science sector and detailing the decrease of women in the middle and upper professional categories in such sector).

5. *But see* NAT'L SCI. BD., *supra* note 2, at 147 (arguing that women only make up 6% of all aerospace, electrical, and mechanical engineers).

6. *See* Motoko Kuwahara, *Japanese Women in Science and Technology*, 39 MINERVA 203, 205 (2001) (citing a 1996 study of women faculty members in the academic fields of science and technology).

7. *See* Mary Frank Fox, *Gender, Hierarchy, and Science*, *in* HANDBOOK OF THE SOCIOLOGY OF GENDER 441, 450 (Janet Saltzman Chafetz ed., 1999) (arguing that 10% of full professors were women relative to 32% of assistant professors); *see also* Stefan Fuchs et al., *Gender, Science, and Scientific Organizations in Germany*, 39 MINERVA 175, 177-78 (2001) (describing the 6% rate of female full-time professors in Germany as very low by international standards); Mauleón & Bordons, *supra* note 4, at 203 (reporting that only 4% of women are employed in Spain's material sciences at the research professor level compared to 44% of tenured scientists in the field).

8. *See* Jennifer Hunt, *Why Do Women Leave Science and Engineering?*, at *3 (Nat'l Bureau of Econ. Research, Working Paper No. 15853, 2010), *available at* http://www.nber.org/papers/w15853 (arguing that attrition appears to be more acute in engineering because women are dissatisfied with payment and promotion opportunities citing also that this is due to lack of mentoring or networks for women); Alejandra Mizala & Pilar Romaguera, *Equity and Educational Performance*, 2 ECONOMIA 219, 250 (2002) (explaining that in Chile's nation-wide schools test, SIMCE, girls have consistently shown better performance in languages).

others have argued that such differences are nonexistent after controlling for demographic, family, and productivity characteristics.[9]

Studies of developed countries that analyze scientific productivity gaps between genders have shown that women are less productive than are men in this realm.[10] Nevertheless, such differences measured through publication counts or weighted by impact factors tend to diminish significantly or even disappear with the inclusion of adequate statistical controls such as rank, network size, family, and demographic characteristics.[11] The literature targets the origins of these differences in both the demand for and the supply of female scientists. Demand factors are those of segregation and access to scientific jobs with similar conditions to men; supply factors reflect the preferences and interests of women in the production of science.[12]

Beyond the debate about the extent to which the different factors explain the relatively small fraction of women engaged in science or how productive they are, the literature also reveals significant gender differences in attitudes towards commercial science. First, the commercialization of university science by women appears to be significantly underrepresented with respect to the already low level of

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9. *See, e.g.*, Donna K. Ginther & Shulamit Kahn, *Does Science Promote Women? Evidence from Academia 1973-2001*, at *2 (Nat'l Bureau of Econ. Research, Working Paper No. 12691, 2006), *available at* http://www.nber.org/papers/w12691 (arguing that the impact of fertility decisions explain the gender gap in tenure positions in the US.).

10. *See* JONATHAN R. COLE & STEPHEN COLE, SOCIAL STRATIFICATION IN SCIENCE 137 (1973) (concluding that family status could not account for the productivity gap between men and women); Henry L. Allen, *Faculty Workload and Productivity: Ethnic and Gender Disparities*, *in* THE NEA 1997 ALMANAC OF HIGHER EDUCATION 25, 36 (Harold Wechsler ed., 1997) (reporting that the male to female productivity ratio for white faculty members was seventeen to three); Mary Frank Fox, *Gender, Family Characteristics, and Publication Productivity Among Scientists*, 35 SOC. STUD. SCI. 131, 143 (2005) (basing the productivity of women on their family composition); Sooho Lee & Barry Bozeman, *The Impact of Research Collaboration on Scientific Productivity*, 35 SOC. STUD. SCI. 673, 679 (2005) (basing the finding on the lower publication rate of women); J. Scott Long, *Measurement of Sex Differences in Scientific Productivity*, 71 SOC. FORCES 159, 167 (1992) (arguing that a reduced number of collaborations including women can account for the gender gap).

11. *See* YU XIE & KIMBERLEE A. SHAUMAN, WOMEN IN SCIENCE: CAREER PROCESSES AND OUTCOMES 188 (2003) (explaining that the introduction of these control variables is necessary to explain the gender gap); Waverly W. Ding et al., *Gender Differences in Patenting in the Academic Life Sciences*, 313 SCIENCE 665, 666 (2006) (finding no difference in the influence of scholarly research between the genders); Fox, *supra* note 10, at 132 (concentrating on the relationship between marriage, children and publication); Mauleón & Bordons, *supra* note 4, at 203 (relying on a study of scientists working in materials science in 2000); Yu Xie & Kimberlee A. Shauman, *Sex Differences in Research Productivity: New Evidence About an Old Puzzle*, 63 AM. SOC. REV. 847, 849 (1998) (arguing that publication statistics may be distorted due to factors such as social pressure).

12. *See* XIE & SHAUMAN, *supra* note 11, at 178 (recognizing that reliance on demand factors must be restricted to doctoral scientists to account for the large variation in results).

female scientists in academia.[13] Moreover, females have lower chances of being affiliated with university research centers engaged with industry in the United States.[14] Compared to male scientists, female scientists tend to exhibit less of an interest in disclosing their inventions.[15] The failure of women to disclose inventions can be interpreted as a reduced overall motivation to obtain a licensing agreement for their inventions.[16] Scientific productivity for commercial science, as measured by patenting activity, appears to be more elusive for female than for male scientists, and such difference appears to be more acute than gender differences in publication rates.[17] Similar findings have been made for the United States[18] and European countries.[19] In fact, a 1999 study by the United States Patent and Trademark Office (USPTO) revealed that no more than 10% of patent applications could be attributed to female inventors.[20]

The reasons for these differences are still unclear. The relative incentive structure of open and proprietary sciences can trigger gender productivity

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13. *See* Peter Rosa & Alison Dawson, *Gender and the Commercialization of University Science: Academic Founders of Spinout Companies*, 18 ENTREPRENEURSHIP & REG'L DEV. 341, 343 (2006) (examining whether seniority is a positive factor for female scientists in the United Kingdom).

14. *See* Monica Gaughan & Elizabeth A. Corley, *Science Faculty at US Research Universities: The Impacts of University Research Center-Affiliation and Gender on Industrial Activities*, 30 TECHNOVATION 215, 216 (2010) (arguing that involvement in industrial research is an important factor for furthering a career).

15. *See id.* (pointing to this finding as evidence that men are disproportionately more involved in industry).

16. *See* Jerry G. Thursby & Marie C. Thursby, *Gender Patterns of Research and Licensing Activity of Science and Engineering Faculty*, 30 J. TECH. TRANSFER 343, 348 (2005) (finding, however, that by the end of their careers, men and women disclose at a very similar rate).

17. *See* Pierre Azoulay et al., *The Determinants of Faculty Patenting Behavior: Demographics or Opportunities?*, 63 J. ECON. BEHAV. & ORG. 599, 615 (2007) (finding that women have only a 49% chance of becoming a first-time patenter).

18. *See, e.g.*, Ding et al., *supra* note 11, at 666 (explaining that being female has a statistically significant effect on a scientist's productivity); Fiona Murray & Leigh Graham, *Buying Science and Selling Science: Gender Differences in the Market for Commercial Science*, 16 INDUS. & CORP. CHANGE 657, 659 (2007) (suggesting that the gap between men and women is most prominent at prestigious institutions); Kjersten Bunker Whittington & Laurel Smith-Doerr, *Gender and Commercial Science: Women's Patenting in the Life Sciences*, 30 J. TECH. TRANSFER 355, 358 (2005) (finding that only 14% of female scientists are patenters).

19. *See generally* Rainer Frietsch et al., *Gender-Specific Patterns in Patenting and Publishing*, 38 RES. POL'Y 590, 594 (2009) (noting that there has been a general trend in increases of the contribution of women, but it is still low); Fulvio Naldi et al., *Scientific and Technological Performance by Gender*, *in* HANDBOOK OF QUANTITATIVE SCIENCE AND TECHNOLOGY RESEARCH, 307 (Henk F. Moed et al. eds., 2004) (finding that a low percentage of female inventors in Germany significantly influences the global statistics on female participation).

20. *See* U.S. DEP'T OF COMMERCE, PATENT & TRADEMARK OFFICE, BUTTONS TO BIOTECH: 1996 UPDATE REPORT WITH SUPPLEMENTAL DATA THROUGH 1999 (1999) (reporting that the percentage share of all patents has shown a significant overall increase in woman-inventor patents since 1977).

differences for alternative forms of scientific production if the origin relates to differences in gender preferences (supply-side constraints). Nonetheless, the set of rules that can govern proprietary science may end up discriminating more strongly against women (demand-side constraints).

Research that clarifies the state of affairs for women in science in developing countries is very scarce. Some reports from Mexico indicate that women do not exceed 2% of Mexican scientists.[21] A limited scope study for the Cordoba region in Argentina revealed a more evenly split divide of scientific output between men and women, but these figures are of local representation.[22] Nonetheless, there are some reports that women have been able to achieve high-ranking positions in scientific societies, including those in developing countries.[23]

III. AN OVERVIEW OF ALTERNATIVE INSTITUTIONAL ARRANGEMENTS AND GENDER: OPEN SCIENCE VERSUS PROPRIETARY SCIENCE

Public policy questions concerning how to best promote and foster innovative and creative activity have surfaced repeatedly since at least the nineteenth century. In a series of essays, Paul A. David has developed a meaningful division of the alternative institutional arrangements: institutions of *proprietary science* and those of *open science*.[24] Although open science is comprised by the set of norms that, among other important features (such as the significance of rewards of a non-pecuniary nature), allow third parties rapid, expeditious, and inexpensive access to the use of

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21. *See* Henry Etzkowitz & Carol Kemelgor, *Gender Inequality in Science: A Universal Condition?*, 39 MINERVA 153, 158 (2001) (noting that even when a woman attains a senior post, a man is still usually in charge); *see also* Jane M. Russell, Los Indicadores de Producción Científica por Género: Un Caso Especial, presented at Tercer Taller de Obtención de Indicadores Bibliométricos, Red Iberoamericana de Indicadores de Ciencia y Technologia y el Centro de Información y Documentación Científica 1, 3 (March 2003) (finding that at the Universidad Nacional Autonaoma de Mexico, which is responsible for about half of the scientific research being done in Mexico, women only account for 25% of the researchers in scientific fields, compared with 51% of the researchers in the humanities).

22. *See* Eugenia Bustos Argañaraz, Alicia Centeno Sosa & María Virginia Rapela, *Análisis bibliometrico de la producción científica de los investigadores con proyectos aprobados por la Secretaría de Ciencia y Tecnología de la Universidad Nacional de Cordoba: 1996-1999*, 15 TRANSINFORMACAO, CAMPINAS 231, 236, 242-43 (2002) (surveying the number of publications produced between 1996 and 1999 by looking at three databases which represented only projects approved by La Universidad Nacional de Cordoba).

23. *See* Marjorie B. Lees, *Participation of Women in Neurochemistry Societies*, 27 NEUROCHEMICAL RESEARCH 1259, 1261 (2002) (explaining that as women became more visible in hosting, organizing, and chairing societal meetings and events, they were increasingly elected to office).

24. *See* David, *Historical Origins*, *supra* note 1, at 9 (distinguishing "open science" from scientific research under commercially-oriented proprietary rules regarding information and from the production and procurement of defense-related scientific and engineering knowledge).

knowledge developed by individuals.[25] Nonetheless, open science institutions do not imply cost-free use of the knowledge made accessible. An important difference between these paradigms is the source of funding and incentives for creative and innovative activities: while proprietary science relies primarily on private funding, open science relies heavily on different types of sponsorship (different types of "subsidies" such as prizes, rewards, and public procurement of either a private or public nature)[26] and market pecuniary rewards. These rewards result from market exclusivity during the period in which competitors strive to compete in the market. As such, they do not differ in nature from those produced by proprietary science institutions. However, they differ in the role played by law in controlling the speed and likelihood of third parties contesting the market.

Examples of both open and proprietary science paradigms have coexisted in societies perhaps since the emergence of open science.[27] However, their relative weight and their interplay have varied in time and place. Since the late eighteenth century, the Western world has actively institutionalized both proprietary and open science institutions to different degrees. In the open science realm, institutionalization had occurred through the establishment of scientific societies (generally in the private sphere) and types of public sponsorship-like systems (such as public prizes and grant schemes for the arts and sciences) as well as by the establishment of peer review rules in both publication and funding application systems.[28]

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25. *See* Michael Polanyi, *The Republic of Science: Its Political and Economic Theory*, *in* KNOWING AND BEING 49, 55 (1969) (believing that open science paradigms enable the advancement of scientific knowledge made by independent scientists). To illustrate this view, he relied on an allegory of a group of individuals trying to solve a gigantic jigsaw puzzle:

> The only way the assistants can effectively cooperate and surpass by far what any single one of them could do, is to let them work on putting the puzzle together in sight of the others, so that every time a piece of it is fitted in by one helper, all the others will immediately watch out for the next step that becomes possible in consequence. Under this system, each helper will act on his own initiative, by responding to the latest achievements of the others, and the completion of their joint task will be greatly accelerated.

Id.

26. These distinctions are made for identification purposes only, as the extent of public funding that supports creation of private IP assets is a moot issue. Paul A. David et al., *Is Public R&D a Complement or Substitute for Private R&D?: A Review of the Econometric Evidence*, 29 RES. POL'Y 497, 498-500 (2000). Similarly, the extent of an innovator's private funding within an open science framework is also the subject of debate. Nevertheless, as a general characterization of these paradigms, the distinction can prove useful.

27. *See* David, *Historical Origins*, *supra* note 1, at 12 (dating the emergence of open and proprietary science paradigms in the seventeenth century).

28. *See, e.g.*, Paul A. David, *Koyaanisqatsi in Cyberspace: The Economics of an "Out-of-Balance" Regime of Private Property Rights in Data and Information*, *in* INTERNATIONAL PUBLIC GOODS AND TRANSFER OF TECHNOLOGY UNDER A GLOBALIZED INTELLECTUAL PROPERTY REGIME 81, 87-88 (Keith E. Maskus & Jerome H. Reichman

In the proprietary science realm, institutionalization had taken place in Western countries by establishing legal protection for IPR. The path followed has been step by step. First, countries strove to establish national systems of IPR protection during the eighteenth to nineteenth century period. This phase was later followed by the creation of an international system of intellectual property protection during the twentieth century. This was in turn followed by the later establishment of a global regime for protection through the World Trade Organization Trade-Related Aspects of Intellectual Property Rights Agreement (WTO-TRIPS) at the end of the twentieth century.[29] Assessing the relative weight each paradigm has attained in the overall incentive scheme for the promotion of knowledge accumulation is not an easy task. The recent sequence of events at a multilateral level point to an inclination of the balance towards a greater pervasiveness of proprietary science institutions compared to open science institutions. According to several authors, the contemporary path of strengthening the proprietary system has weakened the stability and likelihood of the proper functioning and permanence of open science institutions.[30]

In contemporary times, proprietary science institutions are acknowledged as one particular institutional arrangement that aims to provide economic incentives to foster knowledge accumulation.[31] Open science institutions are their complement. Like today, outstanding

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eds., 2005) [hereinafter David, *Koyaanisqatsi*] (discussing patronage as a method of receiving full public disclosure of creative achievements); *see also* B. Zorina Khan, *Looking Backward: Founding Choices in Innovation and Intellectual Property Protection*, *in* FOUNDING CHOICES: AMERICAN ECONOMIC POLICY IN THE 1790S 323 (Douglas Irwin & Richard Sylla eds., 2011) (discussing incentives the colonies provided for new discoveries, enterprises, and contributions).

29. *See* Peter Drahos, *Thinking Strategically About Intellectual Property Rights*, 21 TELECOMM. POL'Y 201, 201 (1997) (noting that the process of trade liberalization produced the TRIPS Agreement).

30. *See* James Boyle, *The Second Enclosure Movement*, *in* THE PUBLIC DOMAIN: ENCLOSING THE COMMONS OF THE MIND 42, 48 (2003) ("Every increase in protection raises the cost of, or reduces access to, the raw material from which you might have built those future products."); *see also* David, *Historical Origins*, *supra* note 1, at 19 (explaining the origins of "open science" as a product of the Scientific Revolution); David, *Koyaanisqatsi*, *supra* note 28, at 83, 119-20 (arguing that the commercial movement is encroaching upon the culture of academic research and challenging "open science").

31. *See* A.L. Keith Acheson & Donald McFetridge, *Intellectual Property and Endogenous Growth*, *in* THE KNOWLEDGE IMPLICATIONS OF KNOWLEDGE-BASED GROWTH FOR MICRO-ECONOMIC POLICIES 187, 213 (Peter Howitt ed., 1996) (stating that intellectual property is just one alternative to facilitate the creation and diffusion of knowledge); Dasgupta & David, *supra* note 1, at 493 (advocating the codification of knowledge); David, *Koyaanisqatsi*, *supra* note 28, at 84 (explaining that the codification of knowledge renders it more easily transmitted, classified, and stored); Richard R. Nelson, *The Simple Economics of Basic Scientific Research*, 67 J. POL. ECON. 297, 297-98 (1959) (noting that society collectively supports a large share of the economy's research).

intellectuals in the past considered the possibility of alternative policies for fostering knowledge accumulation. Major theoretical advocates and skeptics of the proprietary system have recognized that institutional arrangements for promoting and fostering knowledge accumulation need not be exclusively proprietary. However, within the economics discipline, the literature contains an uneven amount of research aimed at analyzing the open science paradigm. Most efforts have been devoted to studying the relative strengths and weaknesses of the proprietary system in the absence of alternative means of promoting knowledge accumulation. Few exceptions analyze properties of open science institutions in contrast to those of proprietary institutions. Since the late eighteenth century, scholars have been interested in studying the effects of pecuniary incentives to promote knowledge accumulation derived from public rewards and from the exploitation of rights granted to exclude third parties from using new knowledge.[32]

As the debate about the adequacy of stronger international IPR protection unravels, another angle of economic and social policy can be examined. To the extent that open and proprietary science institutional frameworks are gender neutral, the outcome of such discussions may be sufficient to provide a comprehensive welfare analysis framework. Nonetheless, if the institutional framework put in place to promote knowledge accumulation has some inherent gender bias, then the welfare considerations need for the assessment of the appropriateness of such framework are considerably more complex than presumed.

If a gender bias can be established for either the open or proprietary systems, then changes in the relative prominence of either institutional framework (open or proprietary) might have a collateral effect in promoting or damaging female involvement in the production of scientific progress. Consequently, the more positive the gender bias of the system,

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32. *See* Robert Andrew Macfie, *The Patent Question Under Free Trade: A Solution of Difficulties by Abolishing or Shortening the Investors Monopoly, and Instituting National Recompenses*, *in* CONGRESS OF THE ASSOCIATION FOR THE PROMOTION OF SOCIAL SCIENCE 8 (1864) (arguing that public use of an invention does not wrong the inventor). *See generally* STAFF OF S. COMM. ON PATENTS, TRADEMARKS, AND COPYRIGHTS OF THE COMM. ON THE JUDICIARY, 85TH CONG., AN ECONOMIC REVIEW OF THE PATENT SYSTEM 19 (Comm. Print 1958); Nancy Gallini & Suzanne Scotchmer, *Intellectual Property: When Is It the Best Incentive System?*, 2 INNOVATION POL'Y & ECON. 5, 51-53 (2002); Khan, *supra* note 28, at 331 (pointing out that Alexander Hamilton advocated for an alternative system to patents); Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137, 1140 (1998); Ugo Pagano & Maria Alessandra Rossi, *The Crash of the Knowledge Economy*, 67 CAMBRIDGE J. ECON. 1, 8 (2009); Michael Polanvyi, *Patent Reform*, 11 REV. ECON. STUD. 61, 62 (1944); Richard E. Romano, *The Optimal R&D Policy: Patents, Public Funding, or Both?*, 57 S. ECON. J. 703, 703 (1991); Steven Shavell & Tanguy Van Ypersele, *Rewards Versus Intellectual Property Rights*, 44 J.L. & ECON. 525, 527 (2001); Brian D. Wright, *The Economics of Invention Incentives: Patents, Prizes, and Research Contracts*, 73 AM. ECON. REV. 691, 691 (1983).

which is becoming more prominent (proprietary as opposed to open, according to some authors), the more positive the effect of female involvement in scientific production. If instead, the gender bias of the more prominent system is negative, then increased female involvement in scientific production would appear to be more troubled.

IV. CHILEAN SCIENTIFIC PRODUCTION

A. Chile in an International Context in Knowledge Production

In 2010, Chile joined the group of thirty countries that make up the Organisation for Economic Co-operation and Development (OECD). In comparison to most of such countries, Chile exhibits a relatively poor performance in scientific production.[33] Table A shows that Chile's academic publications in the Web of Science (WOS) Journals during the second half of the 2000 decade, relative to its population, was equivalent to 20% of the average amount exhibited by other OECD countries. Investment in research and development as a fraction of GDP was also less compared to other OECD countries (only 38% of what other OECD countries spent). The scientific productivity gap is more pronounced in market-oriented innovations (patents). Using different patent filing figures, Chile exhibits no more than 3% of what OECD countries produced on average during the second half of the 2000 decade. Rankings for these indices place Chile last among OECD countries.

33. *See* Nibaldo C. Inostrosa et al., *Publicaciones y Patentes*, *in* ANÁLISIS Y PROYECCIONES DE LA CIENCIA CHILENA 2005, 73 (Jorge Babul et al. eds., 2005) (failing to provide a gender distinction in a scientific productivity study).

TABLE A: SCIENTIFIC PRODUCTION - OECD COUNTRIES

Country	Scientific Production Indices					Rankings				
	WOS Papers	R&D	Patent Filing Avg. 2004-07			WOS Papers	R&D	Patent Filing Avg. 2004-07		
	Avg. '06-09	2004	Any Office	EPO	PCT	Avg. '06-09	2004	Any Office	EPO	PCT
	1	2	3-1	4-1	1	1	2	3-1	4-1	1
Australia	1354	1.78	508	52	100	10	14	20	20	15
Austria	1000	2.26	747	188	146	15	10	12	8	9
Belgium	1155	1.87	650	139	100	14	13	17	10	15
Canada	1292	2.05	630	71	86	11	12	18	18	19
Czech Republic	606	1.25	102	13	14	21	19	24	24	24
Denmark	1641	2.48	1232	205	216	3	9	10	7	4
Finland	1523	3.45	1788	260	290	5	2	5	4	2
France	799	2.15	718	136	103	17	11	14	11	13
Germany	829	2.49	1540	287	206	16	8	8	2	6
Greece	719	0.55	80	9	8	19	28	25	26	25
Hungary	423	0.88	132	15	20	26	24	23	23	23
Iceland	1625	2.82	602	86	120	4	6	19	16	11
Ireland	1391	1.24	673	68	82	8	20	16	19	20
Italy	640	1.1	369	82	51	20	22	21	17	21
Japan	506	3.17	4003	169	185	25	3	1	9	7
Korea	571	2.85	3348	101	119	22	5	2	13	12
Luxembourg	568	1.63	1794	216	93	24	17	4	5	17
Mexico	86	0.43	9	1	2	31	31	31	30	30
Netherlands	1381	1.78	1619	214	207	9	14	6	6	5
New Zealand	1261	1.16	776	40	88	13	21	11	21	18
Norway	1478	1.59	744	98	135	7	18	13	14	10
Poland	353	0.56	67	4	3	28	27	27	28	29
Portugal	571	0.77	41	10	8	22	25	28	25	25
Slovak Republic	402	0.51	74	6	7	27	30	26	27	27
Spain	738	1.06	153	31	30	18	23	22	22	22
Sweden	1747	3.62	1603	274	293	2	1	7	3	1
Switzerland	2150	2.90	3131	414	284	1	4	3	1	3
Turkey	228	0.52	19	3	4	29	29	30	29	28
United Kingdom	1287	1.71	677	89	101	12	16	15	15	14
United States	1482	2.59	1252	114	163	6	7	9	12	8
Chile	**211**	**0.67**	**28**	**1**	**2**	**30**	**26**	**29**	**30**	**30**
OECD-non Chile	**994**	**1.77**	**969**	**113**	**109**					

(1) Per million inhabitants; (2) Relative to GDP based on OECD data; (3) Patent applications to any national offices according to WIPO figures. World Intellectual Property Office, www.wipo.int (last visited Nov. 19, 2010).

B. Gender and Science in Chile

In spite of low participation rates, women in Chile have increased their involvement in the labor market since the 1990s. As shown by Table B and Table C, participation rates in the labor force and in employment increase notably with the level of women's education, which is almost on par with more educated populations. This positive outlook and evolution of the degree of engagement of educated females in the labor market would provide good grounds for optimism about the role played by women in scientific production. However, the information needed to make definite conclusions is not yet available. Nonetheless, some reports indicate that the role of women in scientific production is not significantly different from what has been reported in developed countries. The National Academy of Science examined some disciplines within the scientific community in 2005, and noted that women represented less than 25% of researchers. Table 1 summarizes the gender split found in those studies. Another study, also conducted in 2005, shows that women accounted for 10% of economists with postgraduate degrees in Europe and the United States,[34] but found a less dismal scenario for female researchers engaged in plant sciences (37% at one major research center). Interestingly, figures reported for the European Union (EU) are of similar magnitude. In fact, the figures for the EU showed that 25% of industrial researchers were female.[35] Furthermore, females in some African countries were found to comprise 21% of total researchers.[36] These facts suggest that Chile, and perhaps developing countries more generally, exhibit a gender split similar to developed countries in spite of having a smaller scientific production sector and devoting less investment efforts to producing science.

34. *See* Javier Núñez & Jorge Hermann, *Economistas de Alto Nivel en Chile*, ECONOMIA & ADMINISTRACIÓN, Mar.-Apr. 2005, at 12 (adding that women account for 11% of economists with only master's degrees).

35. EUROPEAN COMM'N DIRECTORATE-GENERAL FOR RESEARCH, *supra* note 3, at 27.

36. *See* B. Paige Miller et al., *Gender and Science in Developing Areas: Has the Internet Reduced Inequality?*, 87 SOC. SCI. Q. 679, 684 (2006) (noting that approximately 26% of women work in universities).

TABLE B: PARTICIPATION OF WOMEN IN THE LABOR MARKET

	Labor Force Level of Education			Employment Level of Education		
Year	**Elementary**	**High**	**University**	**Elementary**	**High**	**University**
1990	28%	39%	43%	28%	39%	43%
1992	30%	38%	45%	29%	37%	44%
1994	30%	37%	47%	29%	36%	46%
1996	31%	38%	47%	31%	37%	47%
1998	31%	40%	47%	31%	39%	46%
2000	34%	40%	46%	33%	38%	46%
2003	33%	41%	43%	32%	40%	46%
2006	35%	41%	48%	34%	40%	47%

Source: CASEN Survey-MIDEPLAN (individuals aged over 15 years). Encuesta CASEN, http://www.mideplan.cl/casen/en/index.html (last visited Nov. 19, 2010).

TABLE C: LEVEL OF EDUCATION AND CHILEAN FEMALE INVOLVEMENT IN THE LABOR MARKET

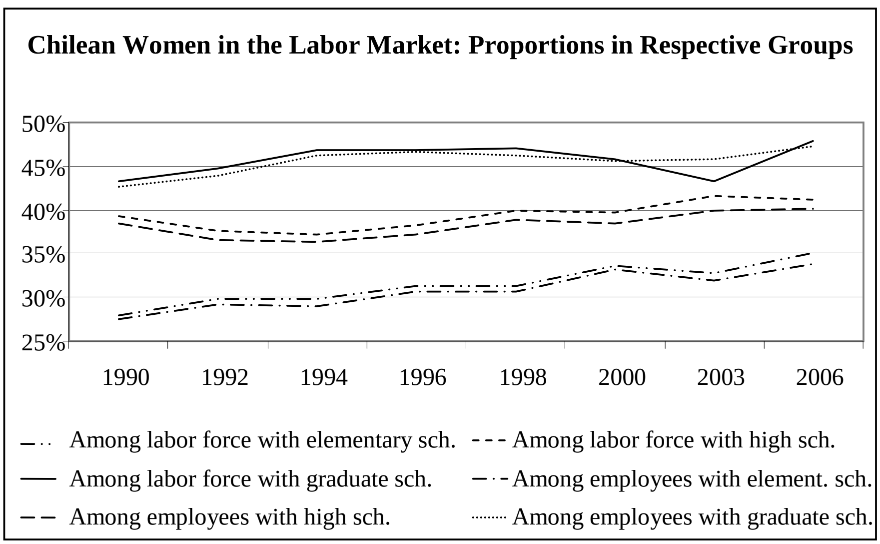

TABLE 1: SCIENTISTS IN CHILE, NATIONAL

Discipline	**Chapter**	**Men**	**Women**	**Total**
Biology	7	64.9%	35.1%	414
Biomedicine	8			
Chemical sciences	9	62.0%	38.0%	50
Math sciences	10			169
Physics	11	88.8%	11.2%	205
Astronomy	12			42
Agronomical and forestry sciences	13	78.0%	22.0%	580
Environmental sciences	14	74.7%	25.3%	170
Engineering sciences	15	87.0%	13.0%	254
Earth sciences	16	78.0%	22.0%	155
Sea sciences	17	76.4%	23.6%	157
Total		**76.7%**	**23.3%**	**2196**

Source: LA ACADEMIA CHILENA DE CIENCIAS, ANÁLISIS Y PROYECCIONES DE LA CIENCIA CHILENA 2005 (Jorge Babul et al. eds., 2005).

C. Is There a Scientific Gender Productivity Gap Between Open and Proprietary Science in Chile?

Scientific productivity might differ between open and proprietary science. People might find it more appealing to produce scientific output through the open science system by writing scientific papers or through the proprietary science system by producing patents. Gender biases in scientific productivity may exist, but one would expect to find them equally present in any form of scientific output if the institutional frameworks for the production of different forms of science are unbiased. If this is so, the proportion of papers authored by women should be similar to the proportion of female inventors in the respective population of patent scientists. A way to test the hypothesis of neutrality of the institutional frameworks is to compare the proportion of Chilean female contributions in scientific papers and in patent filings.

The gender divide of scientific contributions of the population of Chilean inventors and academics has not been carried out to date, perhaps as a result of the lack of data disclosing information about these populations. For this Article, an effort has been made to clarify this issue. Gender identification has been carried out by assigning gender to the forenames of academics and inventors of Chilean scientific contributions. Information was gathered between 1990 and 2007 by retrieving data from the World Intellectual Property Organization (WIPO), USPTO, and Chilean Patent and Trademark Office (DPI-INAPI) websites, and the Chilean public agency in charge of funding research, CONICYT.[37] The results of these efforts are provided below in Table 2.

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37. The list of names and the gender assigned to each of them is not detailed in this Article for space reasons, but are on file with the author.

TABLE 2: WOMEN INVENTORS (WI) IN THE POPULATION OF CHILEAN (CL) INVENTORS (TI)

Year	Women as % Inventors in Patent Filings			Inventors of CL PCT Filings			PCT Applications	
	DPI-INAPI	PCT		Total	CL			
	WI / TI	WI / TI	WI / CL TI		TI	WI	WI	Total
1989		0	0	2	2	0		1
1990	0.00%							
1991	0.90%							
1992	9.90%							
1993	9.00%							
1994	3.70%							
1995	5.90%	33.30%	25.00%	6	4	1	1	1
1996	7.70%	0.00%	0.00%	7	2	0		2
1997	6.30%	0.00%	0.00%	4	3	0		2
1998	9.80%	0.00%	0.00%	1	1	0		1
1999	8.50%	0.00%	0.00%	6	3	0		2
2000	10.20%	9.10%	0.00%	11	5	0	1	3
2001	5.80%	0.00%	0.00%	4	3	0		2
2002	7.20%	11.50%	18.20%	26	11	2	3	7
2003	5.90%	8.80%	9.50%	34	21	2	3	7
2004	6.10%	2.00%	2.80%	49	36	1	1	9
2005	10.40%	6.50%	5.00%	31	20	1	2	6
2006	9.80%	0.00%	0.00%	13	12	0		7
2007	14.00%	24.10%	25.00%	29	28	7	4	7
2008	5.80%	13.30%	10.30%	60	29	3	5	13
Total	**8.10%**	**9.50%**	**9.40%**	**283**	**180**	**17**	**20**	**70**

The identification of Chilean inventors by gender reveals some similarity with figures reported for the United States. Less than 10% of the applicants at the Chilean patent offices were female. Similarly, available disaggregated data for patent applications made through the PCT system with at least one inventor from Chile (seventy cases) in the aggregate, exhibits around 10% of female inventors, either from the population of national inventors or from inventors of any nationality of that set. Disaggregated data on patent applications made in Chile from the 1990s (and published in the official gazette by 2007) indicates that only 6% originated in Chile, and from that subset 9% had at least one female inventor, accounting for over 8% of national inventors. More detailed information can be gathered online from the USPTO database.[38] Patent

38. United States Patent and Trademark Office, Patent Full-Text Databases, http://patft.uspto.gov (last visited Nov. 19, 2010).

applications containing Chilean inventors published by April 2010 (430) had 10% of female inventors from the population of Chilean inventors and 12% of inventors of any origin. Nevertheless, 20% of such applications (90) had at least one female inventor. It appears that from the set of Chilean patent applications, those that seek protection in the United States are applications with relatively more female inventors.

TABLE 3: FEMALE INVENTORS IN CHILEAN PATENT FILINGS IN USPTO

Year	Chilean Inventor			Non Chilean Inventor			Total Inventors			Patent Applications	
	Male	Female (WI)	Total	Male	Female (WI)	Total	Male	Female (WI)	Total	Total	WI
2001	100%	0%	1	100%	0%	6	100%	0%	7	3	
2002	93%	7%	29	93%	7%	27	93%	7%	56	24	3
2003	90%	10%	20	95%	5%	59	94%	6%	79	34	4
2004	90%	10%	30	85%	15%	102	86%	14%	132	52	14
2005	90%	10%	39	93%	7%	76	92%	8%	115	46	7
2006	90%	10%	31	91%	9%	79	91%	9%	110	47	10
2007	93%	7%	30	90%	10%	120	91%	9%	150	76	9
2008	85%	15%	40	83%	17%	156	84%	16%	196	73	23
2009	89%	11%	72	82%	18%	142	84%	16%	214	70	19
2010	75%	25%	4	78%	22%	9	77%	23%	13	5	2
Total	**90%**	**10%**	**296**	**87%**	**13%**	**776**	**88%**	**12%**	**1072**	**430**	**91**

The gender split of academic scientific production (open science) can be estimated through data from academic research proposals made to the corresponding public funding agency in Chile (CONICYT). Data provided by CONICYT reveals a significantly more vigorous involvement of women in academic research than in patent production, with women leading 22% of the projects accepted for funding (see Table 5). CONICYT put together a database of papers published by authors of projects they funded. Although an incomplete set, gender identification of the authors of those papers reveals a similar gender divide (see Table 6), with 20% of papers being written by at least one female author. It is interesting to note that the level of female authorship revealed by this data is similar in magnitude to the share of women in the scientific community in Chile.

TABLE 4: FEMALE INVENTORS IN PATENT FILINGS IN CHILE-DPI/INAPI

Year	Patents Filed & Published in Chile				Women in Chilean Patent Applications	
	Total	Chile	With Female Inventors	Chile/ Total	Filings with Female Inventors Chile	Female Inventors/ Total Inventors Chile
1990	15	1	0	6.7%	0.0%	0.0%
1991	557	91	0	16.3%	0.0%	0.9%
1992	1227	180	21	14.7%	12.2%	9.9%
1993	1428	189	17	13.2%	9.2%	9.0%
1994	1711	223	9	13.0%	4.3%	3.7%
1995	1861	181	13	9.7%	7.4%	5.9%
1996	2153	206	20	9.6%	10.4%	7.7%
1997	2713	144	10	5.3%	7.6%	6.3%
1998	2952	187	17	6.3%	9.7%	9.8%
1999	2936	199	15	6.8%	8.0%	8.5%
2000	3225	194	18	6.0%	9.6%	10.2%
2001	2872	231	14	8.0%	6.3%	5.8%
2002	2527	247	21	9.8%	8.9%	7.2%
2003	2387	248	17	10.4%	7.1%	5.9%
2004	2856	258	19	9.0%	7.6%	6.1%
2005	3029	301	31	9.9%	10.7%	10.4%
2006	3365	270	35	8.0%	13.5%	9.8%
2007	3350	282	43	8.4%	15.8%	14.0%
2008	423	57	3	13.5%	5.8%	5.8%
				5.7%	**9.2%**	**8.1%**
Total	**65197**	**3689**	**323**	**65197**	**3689**	**4944**

TABLE 5: WOMEN IN RESEARCH PROPOSALS FUNDED BY CONICYT

Year	Male-led projects	Female-led Projects	Total	Proportion
1982	101	14	115	12.2%
1983	111	6	117	5.1%
1984	208	37	245	15.1%
1985	224	41	265	15.5%
1986	192	36	228	15.8%
1987	274	65	339	19.2%
1988	332	74	406	18.2%
1989	437	71	508	14.0%
1990	367	85	452	18.8%
1991	416	108	524	20.6%
1992	346	84	430	19.5%
1993	389	114	503	22.7%
1994	354	99	453	21.9%
1995	413	133	546	24.4%
1996	362	104	466	22.3%
1997	309	104	413	25.2%
1998	370	115	485	23.7%
1999	410	116	526	22.1%
2000	404	108	512	21.1%
2001	383	107	490	21.8%
2002	341	97	438	22.1%
2003	350	115	465	24.7%
2004	411	138	549	25.1%
2005	432	122	554	22.0%
2006	525	169	694	24.4%
2007	616	196	812	24.1%
2008	605	258	863	29.9%
2009	507	159	666	23.9%
2010	353	140	493	28.4%
Total	**10542**	**3015**	**13558**	**22.2%**

Additional analysis of scientific productivity under the open science regime relied on WOS publication data. Data was retrieved from WOS in December 2009. Gender was attributed on the basis of the authors' first names and their nationalities on the basis of their affiliation addresses. Only a fraction of the data retrieved disclosed this information (see Table 9 in the appendix).[39] From the set of over 7,000 articles that contained the

39. Articles appearing without a year of publication correspond to unpublished articles accepted for publication. They may be assumed to correspond to 2009 or 2010.

detailed information, nearly 47,000 authors were analyzed, and 37,000 were identified as summarized in Table 7.

TABLE 6: WOMEN IN PUBLICATIONS RESULTING FROM CONICYT FUNDING

Year	Fondecyt Funding Output in Articles				Proportions	
	Male	Female	Unidentified	Total	Women in Publications	Unidentified
	90	38	0	128	30%	0.00%
1967	0	1	0	1	100%	0.00%
1992	2	0	0	2	0%	0.00%
1993	0	1	0	1	100%	0.00%
1995	3	0	0	3	0	0.00%
1996	7	0	1	8	0%	12.50%
1997	10	1	0	11	9%	0.00%
1998	19	1	0	20	5%	0.00%
1999	121	27	2	150	18%	1.33%
2000	370	83	6	459	18%	1.31%
2001	563	115	5	683	17%	0.73%
2002	726	147	5	878	17%	0.57%
2003	820	213	0	1033	21%	0.00%
2004	980	253	0	1233	21%	0.00%
2005	1065	253	0	1318	19%	0.00%
2006	1115	262	0	1377	19%	0.00%
2007	771	194	0	965	20%	0.00%
2008	442	125	0	567	22%	0.00%
2009	101	34	0	135	25%	0.00%
2010	1	0	0	1	0%	0.00%
Total	**7206**	**1748**	**19**	**8973**	**20%**	**0.21%**

The analysis of the WOS data summarized in Table 7 reveals a more optimistic view of women's involvement in scientific production in Chile, as 28% of the authors of relatively recent publications were female academics. Figures from a related exercise, but of a narrower scope, commissioned by CONICYT, revealed that 15% of the authors of scientific articles on immunology, and 20% of the authors of articles on neuroscience, published between 2000 and 2005 were women.[40] The

40. *See* Erwin Krauskopf, *Indicadores de Productividad por Sexo Generados en Chile*, *in* ALGUNAS DISCIPLINAS DEL AREA CIENTIFICA Y TECNOLOGICA 7, 11 (Comision Nacional de Investigacion Cientifica y Technologica ed., 2008) (examining the number of times scientific articles were cited by other works as a means of evaluating actual contribution to the field between the sexes and finding that the greatest disparities in the field of mathematical engineering, and the most uniformity between men and

participation of women in open scientific production, as revealed here, shows a more congruent rate of participation of women in the population of Chilean scientists than that exhibited by proprietary scientific output. However, a more definite conclusion would require a statistical analysis.

Statistically, women in Chile participate differently in the production of scientific output based on the type of scientific contribution they produce and the framework governing scientific work. Female scientific production in open science is relatively more extensive than female scientific production in proprietary science. Table 8 shows that the ratios of women's open science production falls within confidence intervals of 95%, which do not overlap with the equivalent intervals of proprietary science production. Female production in open science would be any level between 18% to 28% with 95% confidence, while female proprietary science production ratios would be any level between 5% to 14% with 95% confidence. The exceptions for these levels are those found in the Chilean patent applications filed through the PCT and USPTO systems.

TABLE 7: ARTICLES PUBLISHED BY FEMALE AUTHORS AMONG AUTHORS FROM CHILE-WEB OF SCIENCE (WOS)

	Male Authors in Articles WOS			Female Authors in Articles WOS			Authors		Female Authors %	
	Chile	**Non-Chile**	**Total**	**Chile**	**Non-Chile**	**Total**	**Identified**	**Scrutinized**	**CL Authors**	**Authors**
	104	61	165	22	25	47	212	330	22%	17%
1970	0	0	0	0	0	0	0	2		
1997	2	0	2	0	0	0	2	2	0%	0%
2002	3	0	3	0	0	0	3	3	0%	0%
2003	3	0	3	0	0	0	3	3	0%	0%
2005	10	1	11	1	0	1	12	12	8%	9%
2006	7	0	7	0	0	0	7	10	0%	0%
2007	1060	307	1367	496	113	609	1976	2310	31%	32%
2008	7376	3900	11276	2827	1282	4109	15385	20892	27%	28%
2009	7468	4667	12135	2940	1524	4464	16599	24144	27%	28%
Total	**16033**	**8936**	**24969**	**6286**	**2944**	**9230**	**34199**	**47708**	**27%**	**28%**

The explanation for these exceptions can be found in the notion that such Chilean patent application populations are but a minor fraction of aggregate Chilean patent applications, which mostly seek protection in Chile (DPI-INAPI). Chilean filings envisaging higher commercial potential, and therefore seeking protection via the USPTO and PCT systems, have greater proportions of female inventors than the Chilean average. In fact, the Z

women in neuroscience).

tests for proportion differences between PCT and USPTO filings involving women, relative to DPI-INAPI filings, appear to be highly significant and therefore suggest rejecting the hypothesis that they correspond with unbiased samples of one population.

Figures suggest that female scientific production in the open science system is greater than the proprietary science system.[41] Yet, the ranges of female open science production levels derived from the different samples analyzed vary from 18% to 28%. Figures derived from WOS seem to belong to a set closer to the universe than the other figures.

TABLE 8: SCIENTIFIC PRODUCTIVITY RATIOS OF WOMEN IN OPEN AND PROPRIETARY SCIENCE

Source	Ratio Data	Women w/r Pop.	Sample	Variance	Min	Max	Δ	Z Test
	Open science							
Table 3	**USPTO CL WI/TI**	0.12	1072	0.00010	0.10	0.14	0.03	2.54
Table 3	**USPTO CL WI/TI CL**	0.10	296	0.00030	0.07	0.13	0.01	0.44
Table 2	**PCT WI/TI**	0.10	283	0.00030	0.06	0.13	0.00	0.17
Table 2	**PCT WI/TI**	0.09	180	0.00047	0.05	0.14	0.00	0.09
Table 4	**DPI/INAPI female inventors/total-DPI**	0.08	4945	0.00002	0.07	0.09	-0.01	-1.79
Table 3	**USPTO CL filings with WI**	0.21	430	0.00039	0.17	0.25	0.12	5.90
Table 2	**PCT CL filings with WI**	0.29	70	0.00292	0.18	0.39	0.19	3.57
Table 4	**DPI/INAPI CL filings with WI**	0.09	3689	0.00002	0.08	0.10	—-	-
	Proprietary science							
Table 5	**Female-led Fondecyt projects**	0.22	13558	0.00001	0.22	0.23	-0.01	-1.12
Table 6	**Female authors Fondecyt publications**	0.20	8973	0.00002	0.19	0.21	-0.03	-3.30
Table 7	**CL female WOS authors**	0.27	11880	0.00002	0.26	0.28	0.04	3.75
Table 7	**Female WOS authors**	0.28	34199	0.00001	0.28	0.28	0.05	5.04
Krauskopf	**CL female authors**	0.20	1138	0.00014	0.18	0.23	-0.03	-2.00
Table 1	**Female scientist / total-ANC**	0.23	2196	0.00008	0.22	0.25	—-	-

Assuming that the 2005 figures revealed by the National Academy of Science on the gender split among the scientific population are close to the figures for the universe and such figure has not varied significantly by 2009, the WOS female production ratios for the 2007–2009 period would suggest that female scientists have been relatively more productive than

41. A weighted average level (by sample size) of female involvement in proprietary science production (9.6%) is slightly less than a third of the weighted average female involvement in open scientific production (25.4%).

men (28% of production compared to 23% of population). Still, a more definitive conclusion in this regard would require more detailed analysis, which could reproduce the implications derived from the above figures.

V. CONCLUSIONS

The path of the increase in IPR protection throughout the world has been a debated subject. No arguments have been raised so far about gender effects of such a path on women engaged in science. This Article has explored this avenue of thought, first by reviewing some literature on institutional frameworks targeting the accumulation of knowledge (open and proprietary science regimens) and the literature on gender and science. On the one hand, it highlights the fact that only a minor fraction of females make up the population of scientists in developed countries. On the other hand, it brings to light the fact that women produce less scientific output under the proprietary science regime compared to what they produce as academics in the open science regime in the developed world. These reports are becoming more frequent at the same time that policy in many countries has been focusing on reducing gender gaps in the scientific world.

This Article explores the degree of the pervasiveness of these findings by analyzing scientific productivity between regimens in Chile, a middle-income economy that has only recently joined the OECD. In light of reports of gender productivity gaps between open and proprietary systems, based on data from the United States and Europe, this Article explores the participation rates of women in scientific output in an economy that allocates less national resources to the production of science than international benchmarks from developed nations. Despite the scale differences between the relative size of the scientific sectors in Chile and the United States or Europe, and the miniscule scientific productivity generated under the proprietary science regime in Chile, the new data produced in this Article reveals that Chile shows similar general gender patterns in the scientific sector to those found in many developed nations. Around 23% of scientists are women, and they account for about 18% to 28% of academic scientific output. Assessing the involvement of women in the production of science under the proprietary science regime, this Article reveals that women as inventors account for about a third (between 5% to 14%) of the scale they represent in academic scientific output under the open science system. These results indicate that gender productivity gaps between regimes of incentives to accumulate knowledge are pervasive across countries, and roughly replicate in economies of different levels of economic development and different orientation towards the production of knowledge.

The reasons that trigger different levels of female involvement in the production of science in different incentive environments needs to be examined in detail. The presence of different financial incentives that characterizes different incentive regimes might be at the core of the phenomena, as suggested by a pilot experimental study in math productivity, where the introduction of financial incentives seems to exacerbate gender differences (with or without the presence of stereotype threat language).[42] This and other factors need to be explored and studied together for acquiring an understanding of the forces driving scientific productivity between genders. Also, the evidence provided in this and other similar studies can be seen as a warning signal that policy makers may need to consider when deciding how much they want to rely on IPR to incentivize knowledge creation, diffusion, and access, when gender considerations form part of their policy objectives.

42. *See generally* Roland G. Fryer et al., *Exploring the Impact of Financial Incentives on Stereotype Threat: Evidence from a Pilot Study*, 98 AMER. ECON. REV. 370 (2008), *available at* http://www.aeaweb.org/articles.php?doi=10.1257/aer.98.2.370 (testing the financial incentive of $2 per correct answer).

VI. APPENDIX

TABLE 9: PUBLICATIONS WITH CHILEAN AUTHORS - WOS

Period	**Articles**	**Sample**	**Total**	**Coverage**
	2	49	51	96.1%
1909-70	220	0	220	0.0%
1970-89	10279	1	10280	0.0%
1990	979	0	979	0.0%
1991	984	0	984	0.0%
1992	1082	0	1082	0.0%
1993	1100	0	1100	0.0%
1994	1095	0	1095	0.0%
1995	1198	0	1198	0.0%
1996	1382	0	1382	0.0%
1997	1432	1	1433	0.1%
1998	1520	0	1520	0.0%
1999	1660	0	1660	0.0%
2000	1716	0	1716	0.0%
2001	1912	0	1912	0.0%
2002	2188	1	2189	0.0%
2003	2367	1	2368	0.0%
2004	2460	0	2460	0.0%
2005	2698	3	2701	0.1%
2006	2891	3	2894	0.1%
2007	2954	479	3433	14.0%
2008	368	3432	3800	90.3%
2009	238	3457	3695	93.6%
Total	**42725**	**7427**	**50152**	**14.8%**

