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Institute of Economics
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Piazza Martiri della Libertà, 33 - 56127 Pisa, Italy
ph. +39 050 88.33.43
institute.economics@sssup.it

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Gender Gap in Patenting Activities: Evidence from Iran

Mojgan Samandar Ali Eshtehardi °
Seyed Kamran Bagheri *

° Institute of Economics, Scuola Superiore Sant'Anna, Pisa, Italy
* Institute of Management, Scuola Superiore Sant'Anna, Pisa, Italy

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Gender Gap in Patenting Activities: Evidence from Iran

Mojgan Samandar Ali Eshtehardi[1]
Seyed Kamran Bagheri[2]

Abstract This study investigated gender differences in innovative behaviour and technological change in Iran by using data on patents granted to Iranians in Iran and their demographic characteristics. Descriptive analysis was used to compare gender involvement and cooperation in patent activities. In addition, an econometric analysis was employed to investigate the statistical significance of the gender differences. The results showed that although females have participated much less than males, the percentage of female inventors has an upward trend over the study period; that might be mainly due to higher women's propensity to engage in team-collaboration that has increased over time. Moreover, the results demonstrated that the probability of female involvement in innovative activities was significantly higher when a state-run company or university was involved while it was lower in the case of private institutions involvement. Compared to other technological sectors, in IPC section D (TEXTILES; PAPER) there was a higher male inter-gender collaboration in favour of significantly higher female participation and contribution. Moreover, after section D, in IPC section A (HUMAN NECESSITIES) the probability of female presence as patentees was higher compared to other sectors. Moreover, unequal geographical distribution among provinces was detected. Potential factors contributing to this disparity remain an open question for further studies.

Keywords: Gender gap, Patent, Iran, Technological change.

1. Introduction

The gender gap in economic activities has long been discussed by scholars and policy makers. Empirical studies have provided evidence that lower female participation in economic activities slows down economic growth and development (e.g., Klasen & Lamanna, 2009; Loko & Diouf, 2009; Esteve-Volart, 2009). The economic gain from encouraging female participation in economic activities is more highlighted in rapidly aging economics when higher women labour force participation can mitigate the impact of a shrinking workforce and boost growth (Elborgh-Woytek, et al., 2013). Moreover, in countries with a high level of women participation in higher education level, encouraging female economic participation can lead to the more skilled labour force (Steinberg & Nakane, 2012).

In this regard, the importance of technological change in comparative advantages of companies and regions has raised a great concern about the role of women in innovative

[1] Istituto di Economia, Scuola Superiore Sant'Anna, Pisa, Italy Email: samandar.mojgan@gmail.com
[2] Istituto di Management, Scuola Superiore Sant'Anna, Pisa, Italy Email: s.bagheri@sssup.it

activities. To reach the highest innovative capacity, it is essential to use human capital efficiently and optimally by lessening gender disparity among scientists and inventors. In turn, for any attempt to improve female involvement in innovation activities, it is initially vital to better understand various aspects of gender differences in innovation process, such as differences in propensity to innovate, different preferences for collaboration as well as differing choices of task.

Regarding the output of the innovative process, scientific publications and patents are commonly used to compare innovative behaviour between genders. Although a large body of literature exists on examining gender disparity among scientists and academic researchers measured by their number of publications, there are a handful of studies into patentees' gender gap. These studies mostly restricted their focus on small-scale surveys (e.g. Hunt, Carant, Herman, & Munroe.; 2013), or, a particular type of technology (e.g. Whittington & Smith-Doerr, 2005) or a particular segment (e.g. Whittington& Smith-Doerr, 2008). Moreover, they have mainly addressed this issue in developed (e.g. Naldi, et al., 2005; Jung & Ejermo, 2014; Mauleon & Bordons, 2010; Frietsche, Haller, Funken-Vrohlings, & Grupp, 2009), rather than developing countries.

This study, with the aim of highlighting women's role in knowledge creation in a developing country, uses demographic information of all granted Iranian patents inside Iran over a five-year period, from 2008 to 2012. The study attempts to answer the following questions: what is the magnitude of gender disparity in knowledge creation activities (mainly measured by patents activities) and its corresponding trend over the study period? Are there differences in female patenting activity by technological sections? Is there any systematic difference between genders in terms of collaboration with other inventors (number of inventors per patent) as well as contributions to various types of legal entities (universities, private companies and research institutes, and state-run companies or research institutes)? And finally, are there gender gap differences among Iranian provinces in this regard?

Following Naldi, et al. (2005), three measures for scientific and technological performance by gender (participation, contribution, and presence) are calculated. In addition, according to Mauleon and Bordons (2010), three indicators of collaboration (Relational contribution–participation rate by gender, Co-inventorship index and Percentage of males' and females' patents with a single inventor) are computed and studied. The methodological approach used in this study is a descriptive analysis. Moreover, an econometrics analysis is employed to better address the questions raised in the study and investigate the statistical significance of possible gender differences.

This study is the first to investigate Iranian gender differences in patent activities in Iran, as a Muslim country, and most likely in a developing country that might help illuminate policy decisions to promote female inventors in the country.

The paper is organized as follows: the next section provides a review of the literature on the gender gap in patent activities as well as studies on Iranian innovative activities by gender. In the Methodology and Data section, procedures used for data collection and analysis are explained. Then, the results of the analysis are reported. The last section is devoted to conclusions and a summary of the main findings.

2. Literature review

2.1. Previous research on patentees gender gap

Naldi et al. (2005) were the first researchers to assess the feasibility of producing patents (and research) and bibliometric indicators by gender of inventors (and authors). They introduced three indicators of gender involvement comprising Participation, Contribution and Presence, and studied a sample of 6 European countries (France, Germany, Italy, Spain, Sweden and the United Kingdom) using the patents published by the European Patent Office (EPO) in 1998. Their results showed a wide gender gap in patent activities and also a dramatic variation in female patentees' involvement among the six countries.

Using contribution indicators, Frientsch, et al. (2009) extended the work of Naldi et al. (2005) to a sample of 14 developed countries for five years (1993, 1996, 1998, 2000, and 2001). Their results confirmed the findings of Naldi et al. (2005). They found that women's contribution to science and technology exhibited an increasing trend while it substantially varied among European countries, being the lowest in Germany (3.2%) and Austria (4.7%) and the highest in Spain (12.3%) and France (10.2%).

Combining career history data and patenting information, Whittington and Smith-Doerr (2005) studied a random sample of life science PhDs in US. Their empirical evidence showed a steady sate of wide gender disparity of scientists engaging in patent activities across time, although the quality and impact of female scientists' commercial work remained the same or better than those of male scientists. The higher value of women's patents was confirmed by McMillan (2009) who studied the US biotechnology industry. He also concluded that at least in the biotechnology industry, research efforts were shifting from male work to the joint work of men and women.

Mauleon and Bordons (2010) studied patentees' information in Spain providing a descriptive analysis of participation, contribution and presence of inventors as well as collaboration indicators by gender over a period of 16 years (1990-2005). Their results indicated that female participation had an increasing trend over time, changing from 9% in 1990 to 18% in 2005. In total, Spanish female inventors participated in only 16% of total patents and represented 13% of inventors and contributed to 9% of patents. The study revealed that female innovations were biased towards specific institutional sectors (public research institutions) and technological sections (A/Human Necessities and C/Chemistry).

Whittington and Smith-Doerr (2008) employed a multivariate regression model of scientific patenting and found, after controlling for education and career-history variables, there was a significant lower probability of patenting by women than men, although, it varied significantly with the organization of scientists' work settings, being lower in more hierarchically arranged organizational settings and higher in flatter, more flexible, network-based organizational settings.

Jung and Ejermo (2014) addressed trends and patterns by three demographic attributes of inventors: age, education background and gender by studying almost all inventors in Sweden over 23 years, from 1985 to 2007. Their findings indicated that inventors gender gap was decreasing but at a slower pace than in other comparable areas of the society.

Using the National Survey of College Graduated in 2003, Hunt et al. (2013) found that women's lower probability of holding any science or engineering degree just explained 7% of the gap in patenting rates. They pointed out that the gender patenting rate gap among S&E degree holders could not be explained by lower women's share of doctoral degrees but by women's underrepresentation in patent-intensive fields of study, especially electrical and mechanical engineering, and in patent-intensive job tasks, especially development and design.

To sum up the main findings of the studies reviewed above, there is a wide gender gap among patentees in the developed countries which has slightly decreased over time. All researchers in this area have examined developed countries and developing countries have not yet been widely studied. In this study, to fill this gap in the literature we study patentees' gender gap in a developing country, Iran.

2.2. Iranian Women in Knowledge Creation Activities in Iran

Studies into the role of women in knowledge creation activities in Iran are mostly limited to studying Iranian researchers who have publications in ISI journals which are affiliated to an Iranian organization and evaluating their productivity based on their number of publications and citations. These studies have reported that female scientists publish at slower rates than their male counterparts. For instance, Mozaffarian and Jamali (2008) observed that females accounted for 6 percent and males for 94 percent of the total articles published in 2003. Studying a more updated and wider time period, Davarpanah and Moghadam (2012) found that 13 percent of articles were accounted for by female researchers for the period 2005-2010.

Davarpanah and Moghadam (2012) argued that as the number of female students has increased, some positive changes have occurred in the contribution of Iranian women to science, although the percentage of increase in the number of publications by female authors has been much less than the percentage of increase in the number of female students in state universities.

Female researchers' productivity also varies across different scientific subjects. Nourmohammadi and Hodaei (2014) observed more women participation in scientific productions in medicinal rather than technical fields that seems to be mainly due to the difference in the number of students in medical fields rather than engineering and technical fields. They found that although there was no significant difference between pure and applied fields of science, there was a significant difference between the scientific productivity of Iranian women in eight high priority fields of science and technology. Focusing on one scientific subject (Nano Science & Technology) Sotudeh and Khoshian (2013) found that although female Nano-researchers were scarce in number, they performed equally in terms of scientific productions and impacts.

Nourmohammadi and Hodaei (2014) also found that the number of single Iranian female authors (1%) was much less than what was observed in Spain (9%). While Iranian scientists showed more interest in making small groups with three authors, Iranian men showed a higher tendency to publish their paper as single authors than women. 99% of studies conducted by Iranian women are joint publications, with women having more cooperation in basic and applied sciences compared to technology. Davarpanah and Moghadam (2012) found that Iranian women preferred to collaborate more with partners from Iran than those from abroad. The findings showed a similar level of impact of male and female publications.

In order to find potential factors inhibiting academic women' productivity, Isfandyari-Moghaddam and Hasanzadeh (2013) found shortcomings in existing laws, stereotypes and beliefs concerning women, family work, social and cultural contingencies, child care and low collaboration with male colleagues as the most important inhibitory factors affecting Iranian women's ability to publish scholarly articles.

Due to the lack of data on patent activities in Iran, no studies have examined Iranian patentees' gender gap. In this study, however, by benefiting from a priority dataset of Iranian patents information, gender disparity among Iranian patentees in Iran is studied.

3. Data collection and methodology

Data management

The dataset used is a subsample of the dataset introduced in the first chapter. It covers all patents granted to Iranian residents and sorted by application date over the period of five years, from 2008 till 2012, comprising 26718 patents. The first-name based gender identification method was used to codify inventors as male or female. Since the majority of first names in Iran are unisex, this study benefited from a high level of accuracy in assigning gender to the patent information. 4 percent of the patents did not contain the name of inventors (that is, 975 patents) and so were excluded from further analysis.

With respect to patents institutional ownership, five cases were addressed. First, no legal entities were involved in the patent. These patents were assigned to "Personal patents", 87% of total patents. In the case the patents owned by universities or other higher educational institutes, it is referred to "University" sector, 4% of the total patent. If patents owned by privet companies or privet research centre it is referred to "Private institute", 5% of the total patents. In the case of patent ownership with state-run companies or state-run research centres, it is referred to "state-run institute", 4% of the total patents. There were only 38 patents for which two legal entities in different institutional sectors collaborated with each other. In these cases, the patent was counted twice for both sectors.

Indicators of technological activities by gender

Following Naldi et al. (2005), several indicators are commonly used to measure different dimensions of scientists' and inventors' involvement in technological activities by gender. Mauleon and Bordons (2010) added some indicators to measure collaboration. By a slight modification of Mauleun and Bordons (2010), the indicators can be classified into "Gender involvement indicators" and "collaboration indicators". Gender involvement indicators comprise Participation, Contribution and Presence. Collaboration indicators comprise Relational contribution-participation rate indicators, Co-inventor index and Single-inventor percentage. Below, a description of the way in which each of these indicators was calculated is in order.

Gender involvement indicators:

Presence: For each patent application the total number of fe/male inventors is counted by considering patent-inventor combination and using the full counting method, whereby an inventor with multiple patents is counted as many times as the number of patents associated with her/him.

Participation: based on this index the number of patents in which at least a wo/man is involved is counted and is referred to fe/male participation. Moreover, the number of patents with only female inventors, male inventors, and both male and female inventors is calculated.

Contribution: To measure fe/male contribution for any given patent the portion of fe/male inventors in relation to all inventors is calculated. This is done by dividing the number of fe/male over total number of inventors involved in each patent, i.e., fractional counting. In this regard, a uniform contribution of all inventors is assumed.

Collaboration Indicators:

Relational contribution-participation rate: This index measures the difference between participation and contribution indexes by calculating the fraction of contribution index over participation rate and subtracting it from 1, (1 - Contribution/Participation). The index varies between 0 and 1. The closer the rate is to 0, the closer is the contribution index to participation index, which is interpreted as the lower inter-gender co-inventorship. The larger the difference between both measures, the closer the rate is to 1, which is interpreted as the higher inter-gender co-inventorship.

Co-inventorship: For any patent associated with fe/male participation, the number of inventors per patent is calculated and referred to as Co-inventorship index.

Single-inventor percentage: Percentage of patents with a single inventor associated with each gender is calculated and referred to as Single-inventor percentage.

In addition to the above-mentioned indicators, for the study of geographical gender disparity, an additional analysis was conducted by comparing the number of female and male inventors with their corresponding population in each province (gender presence per capita).

As shown by Mauleon and Bordons (2010), these indicators complement each other. For example, female participation represents the number of patents with at least one woman. In this indicator, the portion of females in teams of inventors is not taken into consideration and so it might overestimate the involvement of women in predominantly male teams. To deal with this problem, using female contribution indicator, the proportion of women in relation to all inventors is calculated. So, fe/male contribution index would be equal to 1 if all inventors of a given patent are fe/male, and it would be lower as the share of wo/men inventors in the total number of inventors is lower.

The differences between contribution and participation reflect the inter-gender collaboration propensity that is reflected in Relational contribution-participation rate. The higher this ratio is (the closer it is to one) for a given gender, the greater the tendency to collaborate with the opposite sex. To estimate the propensity to collaborate, regardless of inter- or intra-gender collaboration, the two other indicators of collaboration, Co-inventorship and Single-inventor percentage, consider team size.

Analytical Approach

First a descriptive analysis was used to compare the involvement of Iranian women and men in patent activities in Iran. In addition, to test if the gender differences over various technologies and collaboration attitudes are statistically significant, an econometrics analysis is carried out. We run robust Logit regression model of female and male participation and contribution, separately, on dummy variables of institutional sectors, technological sectors and year, as well as the number of inventors. Moreover, to control for geographical effects, dummy variables for provinces were added to the model.

4. Analysis and Results

4.1. Gender gap in knowledge creation activities

Women constitute almost fifty percent of the population in Iran (SCI) and 55% of university enrolment, over the study period (IRPHE). In most fields of study female university enrolment overtakes that of males, except for the field of Engineering, manufacturing and construction, see Figure 1. Considering the total number of students in “science” and “Engineering, manufacturing and construction”, referred to as STEM (science, technology, engineering and mathematics) which played a crucial role in innovation activities, 44 percent were female (IRPHE).

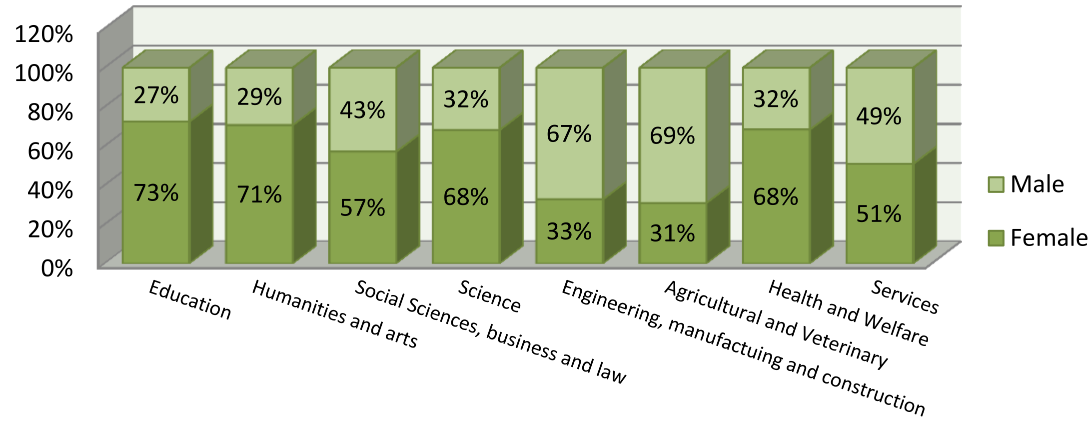


Figure 1: Average gender involvement in higher education by field of study over 2008-2012.

Despite quite close rates of higher education enrolment across genders, gender disparity increases by looking at the workforce in R&D sectors (26 percent of researchers in R&D sectors were female) and professors at higher educational institutes (23 percent were women) (SCI). It is worth mentioning that FLFP in Iran is very limited, accounting for only 16 percent of workforce (SCI). So, one can say that in comparison to the average FLFP rate, the female workforce in knowledge creation activities is quite higher.

Looking at patent activities, however, female involvement is much less than that of males. Figure 2 shows the percentage of presence, participation and contribution of patentees by gender. As it is shown in Figure 2, 14% of all inventors are female; females participated in 20 percent of total patents while their contribution is 12%. These ratios are quite less than the average FLFP rate and much less than the percentage of female researchers or female enrolment in STEM higher education.

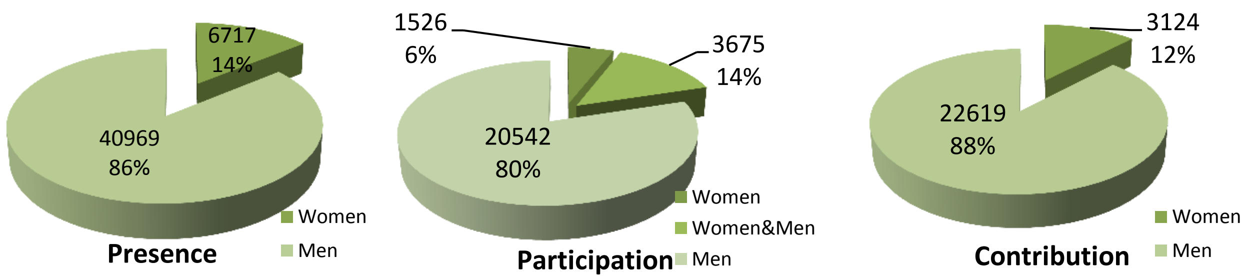


Figure 2: Presence, Participation and Contribution of inventors by gender

The trend of fe/male presence, participation and contribution over the study period is presented in Figure 3. Numbers under the green lines represent the annual change rate of fe/male presence, which is quite the same with regard to other indicators.

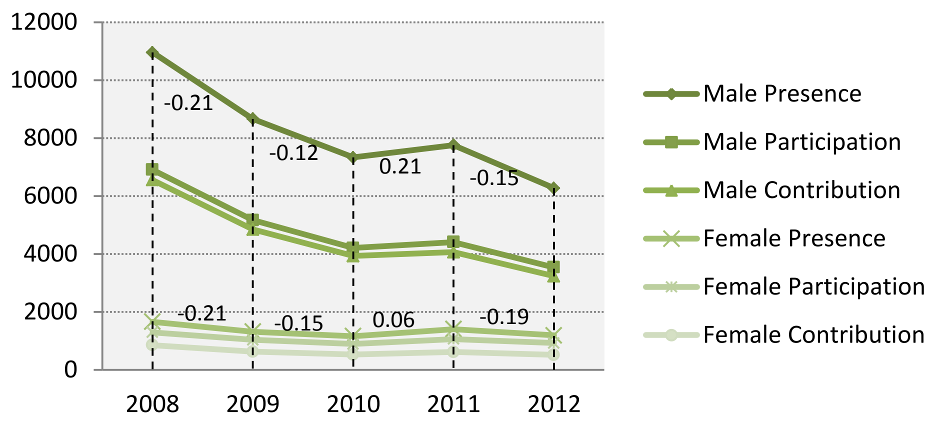


Figure 3: Gender presence, Participation (two categories) and Contribution in patent activities, 2008-2012

As Figure 3 shows, more strict examination on patent application in 2008, which caused a dramatic decrease in the number of total patents (discussed in the first chapter), had almost the same effect on both genders, where the percentage of changes in male and female involvement was almost the same over the time.

Figure 4 presents the changes in involvement indicators by gender over time. It can be seen from Figure 4 that percentage of females' involvement in patent activities has a slightly increasing trend. Women participated in almost 17% of patents in 2008 and 25% of patents in 2012, while male participation was almost fixed at around 94%. Women's presence raised from 13% to 16% and their contribution increased from 11% to 14% over the study period. That is while the percentage of men's presence and contribution had a decreasing trend, from 87% to 84% and from 89% to 86%, respectively.

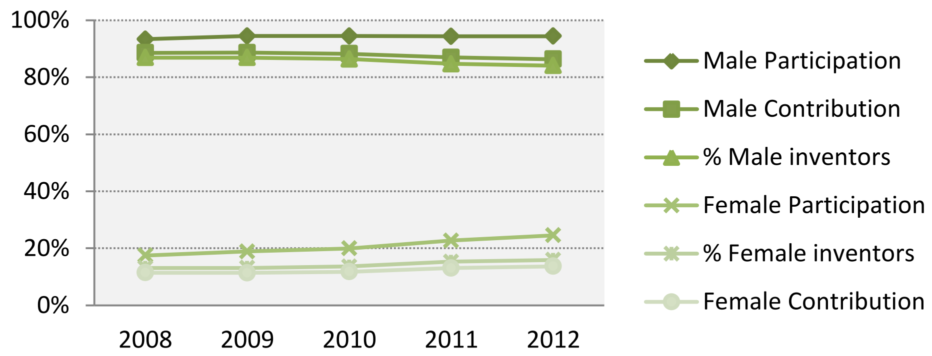


Figure 4: Percentage of gender presence, Participation (Two categories) and Contribution in patent activities, 2008-2012

4.2. Gender co-inventors

Looking at gender collaboration indicators presented in Figure 5 shows that female inventors collaborated more often than men. Just 22 percent of total patents in which women participated were by single inventors while single male inventors were involved in almost 50% of total innovations where at least one man was involved. Moreover, the average number of inventors corresponding to patents with women's participation was around 2.6 while this value for men was 1.9.

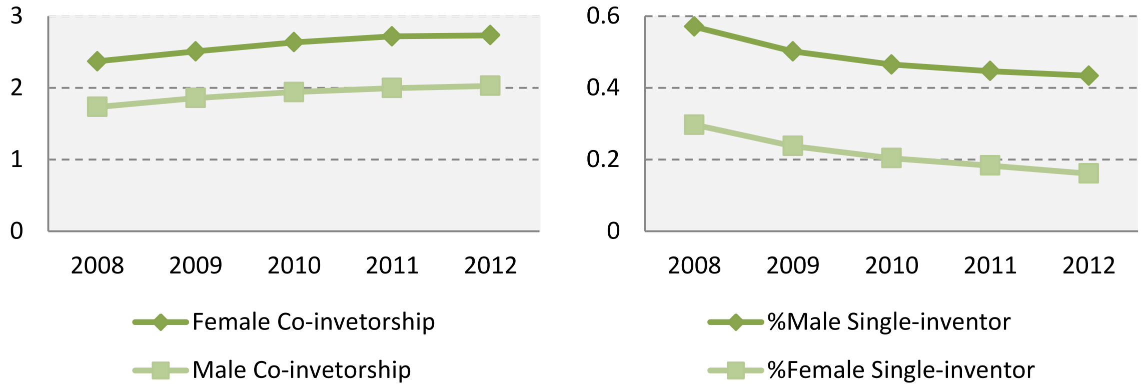


Figure 5: Gender Co-inventorship and Single-inventor percentage, 2008-2012

As Figure 5 shows, the increasing trend of co-inventorship and the decreasing trend of single-inventor is indicative of the fact that collaboration has increased over time for both genders.

Moreover, looking at the relational contribution-participation rate in Figure 6, one can see that collaboration between genders also increased over time as the rate increased for both genders. The rate was higher for female inventors than male inventors (the contribution of women was 30% less than their participation while the ratio is around 9% for men), showing the higher tendency of females to be involved in inter-gender collaboration.

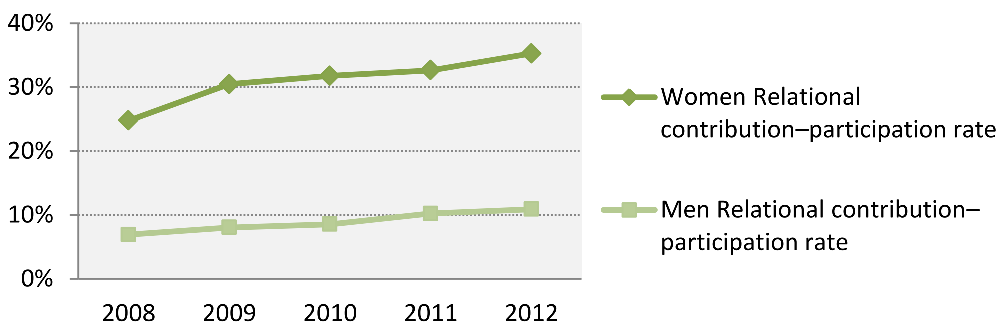


Figure 6: Gender Relational Contribution-Participation Rate, 2008-2012

To better understand the pattern of changes in gender collaboration, we focused on the data on patents by more than one inventor and classified them by patents invented by just women, by just men and those by collaboration of both genders, summarized in Figure 7. The results shows that the percentage of patents in which just females were involved was almost fixed over the period. That is while the percentage of patents by just men's collaboration had a decreasing trend in favour of patents to which both genders contributed.

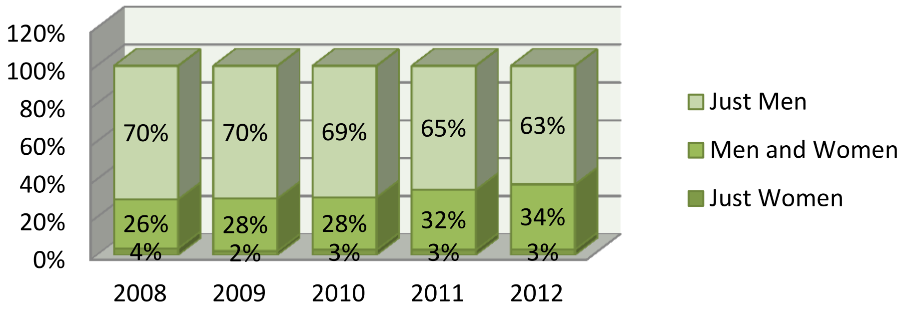


Figure 7: Gender Participation in patent activities with more than one inventor, 2008-2012

Thus, based on all above-mentioned results, we can conclude that men appeared as single inventors more frequently than women and they collaborated less frequently with other inventors. However, the collaboration between two genders has increased over time.

4.3. Gender gap among Patentees across technological sections

In this section, we explore gender involvements in patent activities in different technological sections based on IPC section level. Looking at the presence of fe/male inventors in each technological sector, illustrated in Figure 8, we can see a very similar pattern for both genders. That is, Iranian inventors regardless of gender have the highest activities in sections F and C and the lowest activities in sections D and E. The results are the same based on participation and contribution indicators, as can be seen in Figure 9.

However, looking at each technological section, the percentage of female inventors is higher in section D and A, Table 1. Except for these two sections, the percentage of female inventors is almost the same in all other technological sectors, that is, 13%-14% based on Presence, 5% and 6% based on Participation and 11% or 12% based on contribution.

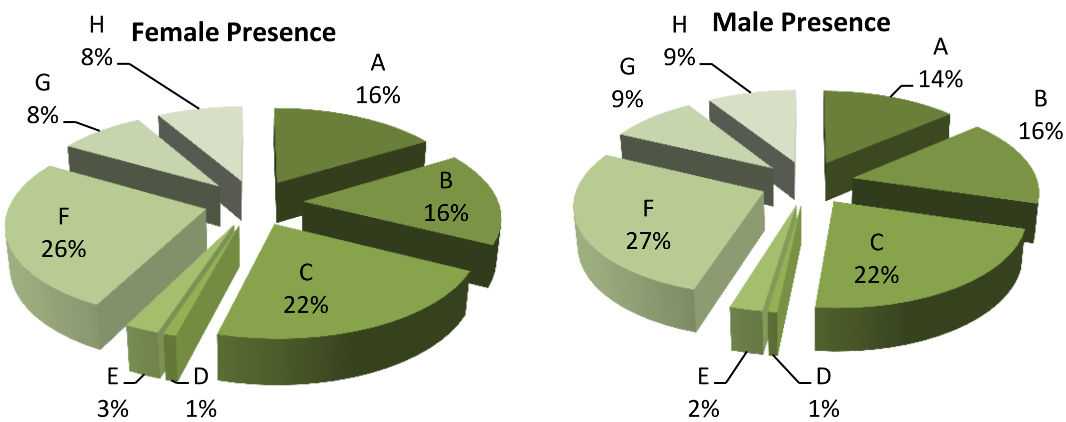


Figure 8: Gender presence in patent activities in different technological sectors

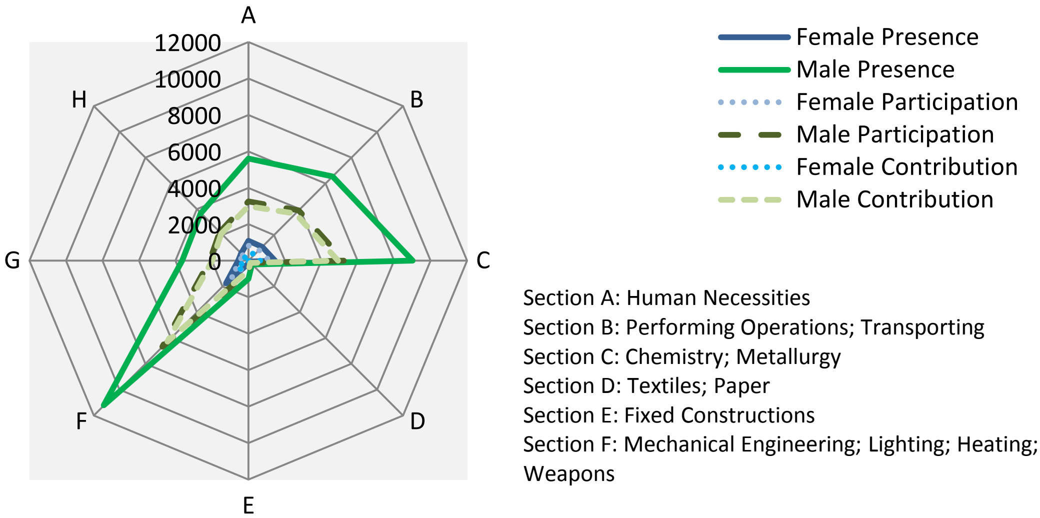


Figure 9: Gender Presence, Participation and Contribtuion in different technological sections

Table 1: Technological activities across genders in different technological sections

	Presence		**Participation**			**Contribution**	
	Female	Male	Female	Female & Male	Male	Female	Male
A-HUMAN NECESSITIES	16%	84%	7%	17%	76%	14%	86%
B-PERFORMING OPERATIONS; TRANSPORTING	14%	86%	6%	14%	80%	12%	88%
C-CHEMISTRY; METALLURGY	14%	86%	6%	14%	80%	12%	88%
D-TEXTILES; PAPER	17%	83%	7%	19%	74%	16%	84%
E-FIXED CONSTRUCTIONS	14%	86%	5%	15%	80%	12%	88%
F-MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS;	13%	87%	6%	13%	81%	11%	89%
G-PHYSICS	13%	87%	6%	15%	80%	12%	88%
H-ELECTRICITY	13%	87%	6%	12%	82%	11%	89%
Grand Total	14%	86%	6%	14%	80%	12%	88%

Table 2 depicts gender collaboration in different technological sectors. From we can observe the higher women's level of collaboration than that of men with almost the same pattern in all IPC sections. The average number of inventors per patent in which at least one female innovator collaborated slightly varied between 2.46 (in section H) and 2.75 (in section F), and for those patents in which at least one male participated varied between 1.82 (section E) and 1.96 (section A); The percentage of female single inventors compared to total female participation varied between 20% (section B) and 38% (section E) while this percentage for male varied between 46% (in section A) and 52% (in section H); and, relational contribution participation rate varied between 38%(in section H) and 42% (in section E) for females and between 6% (in section H) and 9% (in section A) for male.

To sum up, regardless of the technological section, the relational contribution-participation rate and co-inventorship indicators are much higher and single-inventor percentage is much lower for female inventors than that for male inventors. In section H there was the lowest contribution among inventors regardless of gender. In section A, men had the highest inter-gender collaboration (9%) compared to other sections while the average of team size with male participation was the smallest in this section, i.e., 1.53.

Table 2: Collaboration across genders in different technological sectors

	Relational contribution-participation rate		**Single-inventor percentage**			**Co-Inventorship**		
	Female	Male	Female	Male	Total	Female	Male	Total
A-HUMAN NECESSITIES	40%	8%	22%	46%	41%	2.62	1.96	1.64
B-PERFORMING OPERATIONS; TRANSPORTING	41%	7%	20%	51%	46%	2.62	1.87	1.61
C-CHEMISTRY; METALLURGY	40%	7%	23%	49%	44%	2.57	1.91	1.64
D-TEXTILES; PAPER	40%	9%	24%	51%	45%	2.47	1.87	1.53
E-FIXED CONSTRUCTIONS	42%	7%	26%	51%	46%	2.75	1.92	1.63
F-MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS;	40%	6%	22%	50%	45%	2.57	1.86	1.61
G-PHYSICS	41%	7%	22%	49%	44%	2.51	1.90	1.63
H-ELECTRICITY	38%	6%	24%	52%	48%	2.46	1.82	1.60
Grand Total	40%	7%	22%	49%	51%	2.58	1.89	1.85

4.4. Gender gap among patentees in different institutional sectors

The percentage of individual inventors in different institutional sectors showed the same pattern for both genders with the highest portion of individual inventors (personal) and the lowest amount of collaboration with private institutions regardless of gender (see Figure 10).

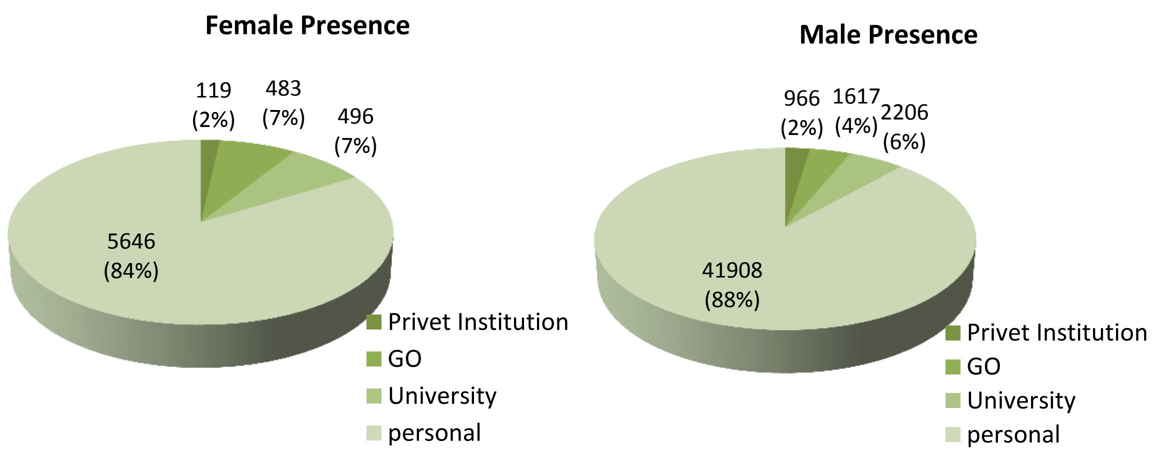


Figure 10: Presence in patent activities across genders in different Institutional sectors

Looking at the data for each institutional sector, summarized in Table 3, it can be seen that the percentage of female inventors is the highest in state-run institutions, in that as to the inventors' collaboration with these institutions, 23% are female with the contribution of 25%

and participation of 46%. The percentage of women contribution is the lowest in privet sections compared to other sections as just 11% of inventors collaborating to private institutions were female.

As Table 4 shows, Female co-inventorship was higher in collaboration with the university sector (based on all three collaboration types) and was the lowest when there were no legal entities involved (Personal patents) and in collaboration with private institutions, respectively. While men co-inventorship was the highest in collaboration with state-run companies, the average team size in patents with male participation was 2.77 while they had the highest inter-gender collaboration, with Relational contribution–participation rate being at 16%. The opposite relation holds in the case of collaboration with private institutions, where the lowest male inter-gender co-inventorship and team size and the highest portion of patent with single male inventors could be observed.

Table 3: Technological activities across gender in different institutional sectors

	Presence		**Participation**			**Contribution**	
	Female %	Male %	Female%	Female & Male%	Male%	Female %	Male %
Privet Institution	11%	89%	4%	11%	85%	9%	91%
Personal	13%	87%	6%	13%	81%	11%	89%
University	18%	82%	7%	29%	64%	19%	81%
State-run institute	23%	77%	11%	36%	54%	25%	75%
Grand Total	14%	86%	6%	14%	80%	12%	88%

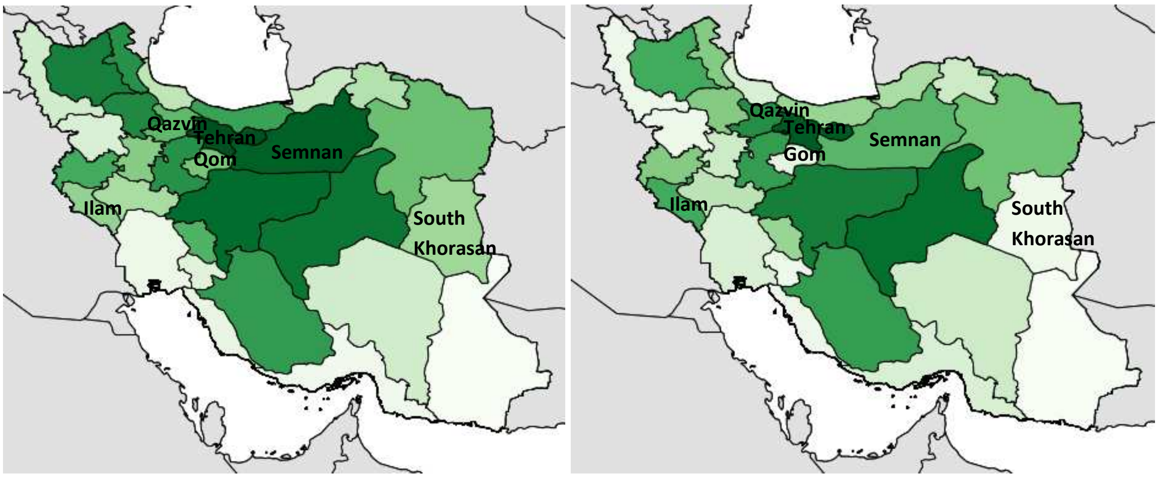
Table 4: Contribution across gender in different institutional sectors

	Relational contribution–participation rate		**Single-inventor percentage**		**Co-Inventorship**	
	Female%	Male%	Female%	Male%	Female	Male
Privet Institution	41%	5%	25%	57%	2.86	1.82
Personal	39%	6%	23%	52%	2.51	1.83
University	48%	12%	13%	17%	2.95	2.64
State-run institute	46%	16%	15%	19%	2.97	2.77
Grand Total	40%	7%	22%	49%	2.58	1.89

4.5. Gender gap within Iranian provinces

In this section, we look at gender disparity among patentees across different provinces. Figure 11a and Figure 11b show male and female presence per capita, respectively, using QGIS software. The darker the colour is, the higher the number of inventors per capita for each gender. As the figures illustrate, not all provinces with higher numbers of male inventors per capita are those where women have the highest evolvement rate in patent activities and vice versa. For example, provinces like Qom, Semnan and South Khorasan have relatively much higher male presence than female presence while in some provinces like Ilam and

Qazvin female inventors are relatively more active than male inventors. So it can be concluded that gender involvement as patentees has an unequal geographical distribution among provinces.



(a)Male presence per capita by province (b) Female presence per capita by province

Figure 11: Geographical distribution of patentees across genders

4.6. Econometrics Analysis

This section aims to test if differences in gender involvement in patent activities are statistically significant by employing econometrics analysis. As mentioned earlier, we used female and male participation and female contribution as dependent variables (the sum of female and male contribution is equal to 1. So, the odd ratio of male contributions is the inverse of the odd of female contributions). Fe/male participation is considered as a dummy variable equal to 1 if at least one fe/male participated in a patent and 0 otherwise. Female contribution is a fractional variable with the following interpretation: as closer to 1, there is the highest female contribution in a given patent and in the case of 0 no female contributed to the patent and all inventors are male. These variables are regressed, separately, as a function of dummy variables of IPC code, dummy variables of Institutional sectors, and dummy variables of year. A variable for the number of inventors is added to control for the effect of collaboration. We also control for the factors associated with provinces by adding their corresponding dummy variables.

The omitted dummy variable in each category, to address multicollinearity, is as considered as the one with the highest portion of total patents. In other words, regarding the institutional sector the variable of "Personal" and regarding IPC variables, the variable corresponding to the section F are omitted as they had the highest portion of innovation from total patents granted in Iran. This is just for convenience and it does not have any effect on the interpretations.

The estimated odd ratio and z value (in parentheses) for female and male participation are presented in

Table 5 and the data for female contribution are shown in Table 6. The results are robust for both indicators (female participation and female contribution) showing that compared to Personal patents, the probability of female involvement in patent activities is significantly higher when a state-run company or university is involved, while it is significantly lower in the case of private institutions. As an example, for state-owned companies the odd of female participation in a patent is 3.6 times larger than the odds of female participation in a Personal patent. The probability of male participation is significantly lower in collaboration with universities and state-owned companies compared to collaboration in Personal patents while males' tendency to patent in collaboration with private companies is not significantly different from their tendency to be involved in a Personal patent.

Regarding the technological section, in IPC section A (HUMAN NECESSITIES) the probability of an inventor to be female is significantly higher compared to other sections; the odd of female participation and contribution is 1.2, while the odd of male participation (and contribution) is 0.8. The odd of females' participation and contribution in section D (TEXTILES; PAPER) is relatively higher compared to other sections. However, male participation is not significantly different in section D compared to the reference section. Thus, the results indicated that there is a higher inter-gender collaboration in section D in the favour of higher female involvement. Moreover, the coefficient of female contribution in section D loses its significance when the dummy variables of provinces are added to the model. This might be because the provinces which are more active in section D tends to welcome female patentees.

Team size positively affects both female and male participation in patent activities. Ceteris paribus, 1 unit increase in team size leads to 80% increase in the odd of female participation and 130% increase in the odd of male participation, which is in favour of higher female contribution, i.e., 20% increase in the odd of female contribution.

Female participation significantly increased over the study period. This is also the case for male participation. This occurred because inter-gender collaboration increased over time and that is why by controlling the effect of collaboration, the years' dummy variable loses their significance.

It is worth mentioning that in running the regressions with response variables as "just female participation", "just male participation", and "participation across genders" confirms that the odd ratio of all inventors of a patent to be unisex has a significant decreasing trend over time. However, the odd ratio of a patent to be invented by inter-gender co-inventorship significantly increased over time.

Table 5: Odds Ratio (Participation across genders)

	Female Participation			Male Participation		
	model(1)	model(2)	model(3)	Model(4)	Model(5)	Model(6)
Personal (reference group)						
State-run institute	3.61***	2.54***	2.33***	0.51***	0.31***	0.35***
	(17.43)	(11.32)	(10.16)	(-5.57)	(-9.42)	(-8.36)
University	2.37***	1.66***	1.63***	0.74*	0.45***	0.46***
	(13.08)	(6.93)	(6.69)	(-2.50)	(-6.35)	(-6.37)
Privet Institution	0.72**	0.70**	0.69**	1.33	1.41	1.47
	(-2.88)	(-2.96)	(-3.10)	(1.41)	(1.68)	(1.89)
F-MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; (reference group)						
A-HUMAN NECESSITIES	1.17**	1.20**	1.18**	0.77**	0.78**	0.79**
	(2.97)	(3.23)	(3.01)	(-2.94)	(-2.83)	(-2.62)
B-PERFORMING OPERATIONS; TRANSPORTING	1.01	1.02	1.02	1.02	1.03	1.04
	(0.24)	(0.45)	(0.39)	(0.19)	(0.36)	(0.44)
C-CHEMISTRY; METALLURGY	1.05	1.05	1.04	0.92	0.92	0.94
	(1.05)	(1.01)	(0.89)	(-1.04)	(-1.04)	(-0.80)
D-TEXTILES; PAPER	1.41*	1.53*	1.51*	0.71	0.72	0.76
	(2.06)	(2.44)	(2.34)	(-1.20)	(-1.17)	(-0.97)
E-FIXED CONSTRUCTIONS	0.97	0.97	0.96	1.02	1.07	1.08
	(-0.32)	(-0.28)	(-0.33)	(0.10)	(0.34)	(0.43)
G-PHYSICS	1.04	1.04	1.04	0.98	0.98	0.98
	(0.71)	(0.67)	(0.61)	(-0.17)	(-0.18)	(-0.16)
H-ELECTRICITY	0.94	0.96	0.96	0.97	0.99	0.99
	(-0.91)	(-0.62)	(-0.65)	(-0.32)	(-0.11)	(-0.09)
Year 2008 (reference group)						
2009.year	1.12*	1.04	1.04	1.22*	1.13	1.13
	(2.41)	(0.82)	(0.80)	(2.57)	(1.58)	(1.61)
2010.year	1.17**	1.04	1.05	1.25**	1.11	1.09
	(3.17)	(0.73)	(0.95)	(2.73)	(1.30)	(1.01)
2011.year	1.32***	1.16**	1.18**	1.27**	1.11	1.08
	(5.84)	(2.99)	(3.28)	(2.99)	(1.32)	(0.92)
2012.year	1.40***	1.23***	1.24***	1.32**	1.15	1.14
	(6.69)	(3.89)	(4.02)	(3.26)	(1.60)	(1.51)
Number of inventors		1.80***	1.80***		2.3***	2.29***
		(38.90)	(38.60)		(17.93)	(17.93)
Provinces			YES			YES
_cons	0.19***	0.06***	0.06***	14.89***	4.69***	3.62***
	(-40.81)	(-53.70)	(-27.62)	(41.43)	(18.47)	(9.11)

Number of observation: 25781
z statistics in parenthesis
* p<0.05 ** p<0.01 *** p<0.001

Table 6: Odds Ratio (Contribution across genders)

	Female Contribution		
	Model(7)	Model(8)	Model(9)
Personal(reference group)			
State-run institute	2.49***	2.13***	1.95***
	(13.90)	(10.85)	(9.50)
University	1.76***	1.53***	1.52***
	(9.08)	(6.59)	(6.46)
Privet Institution	0.72**	0.72**	0.71**
	(-2.75)	(-2.71)	(-2.85)
F-MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; (reference group)			
A-HUMAN NECESSITIES	1.22***	1.22***	1.20***
	(3.68)	(3.72)	(3.46)
B-PERFORMING OPERATIONS; TRANSPORTING	1.00	1.00	1.00
	(0.03)	(0.09)	(-0.01)
C-CHEMISTRY; METALLURGY	1.06	1.05	1.04
	(1.18)	(1.11)	(0.91)
D-TEXTILES; PAPER	1.40*	1.42*	1.37
	(1.97)	(2.03)	(1.84)
E-FIXED CONSTRUCTIONS	0.97	0.97	0.97
	(-0.27)	(-0.24)	(-0.32)
G-PHYSICS	1.03	1.03	1.03
	(0.47)	(0.489	(0.42)
H-ELECTRICITY	0.98	0.99	0.98
	(-0.32)	(-0.20)	(-0.25)
Year 2008 (reference group)			
2009.year	1.00	0.98	0.98
	(0.10)	(-0.36)	(-0.33)
2010.year	1.02	0.98	1.00
	(0.39)	(-0.38)	(-0.07)
2011.year	1.10*	1.05	1.07
	(2.00)	(1.02)	(1.38)
2012.year	1.12*	1.07	1.08
	(2.31)	(1.36)	(1.45)
Number of inventors		1.21***	1.20***
		(17.31)	(16.65)
Provinces			Yes
_cons	0.12***	0.09***	0.09***
	(-50.40)	(-50.85)	(-25.52)

Number of observation: 25781
z statistics in parenthesis
* p<0.05 ** p<0.01 *** p<0.001

5. Summery

The importance of females' involvement in patent activities in boosting economic growth has motivated researchers to examine patentees' gender gap. A number of studies have investigated inventors' propensity to patent across genders in advanced economies; however, less attention has been paid by researchers to less developed countries.

In this study, using a sub-sample of the dataset introduced in the first chapter, patent information granted in Iran to Iranian residents for five years, from 2008 till 2012, was examined to investigate female patentees' role in innovative activities in Iran. The sex of inventors was defined based on their first name. The study benefitted from a high accuracy in assigning the gender of inventors, as the majority of first names in Iran are unisex.

The study conducted descriptive and econometric analysis. Following Naldi et al. (2005) and Mauleon and Bordons (2010), different measurements of gender involvement (comprising Presence, Participation and Contribution) and indicators of collaboration (comprising Relational contribution–participation rate across genders, Co-inventorship index and Percentage of males' and females' patents with a single inventor) were calculated and analysed. Using various indicators, different dimensions of gender involvement were considered. For example, female presence represented the frequency of female inventors, female participation indicated the frequency of patents with at least one female inventor, and female collaboration indicated the fraction of female inventors in the total number of inventors. Relational contribution–participation rate represented a measurement of inter-gender collaboration while Co-inventorship index and Percentage of patents with a single inventor were related to measuring collaboration based on team size.

- Magnitude of patentees' gender disparity and its trend

The findings of this study indicated that only 14% of inventors in Iran were females who participated in 20% of patents and contributed to 12% of technological output over the study period. The rate of female involvement in patent activities showed an upward trend with a relatively sharper increase for female participation (from 17% in 2008 to 25% in 2012) and a slight increase in female contribution (from 11% in 2008 to 14% in 2012) and female presence (from 13% in 2008 to 16% in 2012). Consequently, the proportion of male contribution to all patents and the percentage of male inventors decreased slightly. However, the percentage of patents with male participation slightly increased over time compared to the first year, i.e., 2008. That is because of increase in inter-gender co-inventorship among patentees over the time.

- Gender differences in propensity to co-inventorship

The average team size with female participation was 2.6 while it was 1.89 for patents with male participation. Moreover, males appeared as a single inventor more often than women. However, in both genders the team size showed an increasing trend over time.

The results showed that inter-gender collaboration increased over time. Females always had almost 2.5 times more tendency to collaborate with their inter-sex counterparts compared to their male counterparts.

Increase in team size had a positive effect on both male and female participation in patent activities, one unit increase in team size led to 1.8 and 1.3 times increase in the odd of women's and men's participation, respectively. This is in the favour of female contribution, it led to an increase in the odd of women's contribution by 1.2 times.

- Gender propensity to collaborate with different institutional sectors

The results showed that there was a systematic difference between the two genders' tendency to collaborate with various types of legal entities. The probability of female participation and contribution in a patent owned by a state-owned company or a university or other higher educational institutions was significantly higher than that for Personal patents and was significantly lower in the case of collaboration with a private Company. However, the probability of males' participation in collaboration with a private company was not significantly different from that with Personal patents but was significantly less in the case of collaboration with state-owned companies or universities.

Men had the highest inter-gender co-inventorship in collaboration with state-owned companies and lowest in the case of collaboration with private institutions. In other words, state-owned companies, in contrast with privet institutions, seem to provide better environment for inter-gender collaboration in the favour of higher female involvement in patent activities.

- Preferences for technological activities across genders

There was a significantly higher probability of a patent with female involvement in IPC section A (HUMAN NECESSITIES) and section D (TEXTILES; PAPER). In section A, the odd of a patent with male participation was almost 20% lower than that of the reference section, section F(MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS), while the odd of patents with female participation and female contribution was almost 20 times higher. In section D (TEXTILES; PAPER) there was a higher inter-gender collaboration in favour of higher female participation and contribution but no significant change in male participation. The higher contribution of female in section D might be due to economic and socio-cultural effects of provinces, the provinces which are more active in section D might be those which tend to welcome female patentees more than other provinces.

- Gender gap differences among Iranian provinces

Looking at geographical distribution of female and male presence per capita (the total number of fe/male inventors compared to fe/male population in the provinces) within Iranian provinces indicated a significant different gender gap among the provinces. While in some provinces male innovators had a relatively high presence, the number of female patent-inventor per capita was very low, e.g., Qom, Semnan and South Khorasan. In contrast, some provinces had a relatively low males' presence, but they had a relatively high female patentees' presence, e.g., Ilam and Qazvin. The reasons for the unequal gender disparity among provinces remain an open question which requires further research to unravel the factors underlying this issue.

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