Innovative women: an analysis of global gender disparities in patenting[1]

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Introduction

Innovation is critical to economic development (Schumpeter, 1934) and depends upon the full participation of the scientific workforce (Hunt, Garant, Herman, & Munroe, 2013). Yet, the field of "innovation studies" (Fagerberg, Fosaas, & Sapprasert, 2012) demonstrates that there are many disparities in the exploitation of human capacity for innovation. Foremost among these is the dearth of female inventors (Ding, Murray, & Stuart, 2006; Thursby & Thursby, 2005; Whittington & Smith-Doeer, 2005). The first patent granted to a woman was in 1637; however, female contribution failed to exceed more than 2% through the first half of the 20th century (Jaffe, 2003). Contemporary studies have shown that fewer women patent and when they do, they produce fewer patents per person than men (Ding, Murray, & Stuart, 2006). A number of correlates have been noted: women with higher degrees are more likely to patent than those without (Hunt, Garant, Herman, & Munroe, 2013), and when women inventors are involved, patents tend to have higher diversity in terms of the number of IPC codes assigned (Meng & Shapira, 2011).

The need to understand inventor diversity in patenting was stressed in the America Invents Act (2010), which mandated that the USPTO "establish methods for studying the diversity of patent applicants" (Pub.L. 112-29). The Federal Register (Focarino, 2013) disclosed the first analysis of the 2005-2006 USPTO data, discussed the poor matching with Census data, and called for others to study the diversity of patent applicants. Previous work in this area has relied on purposive sampling of specific populations (e.g., all college graduates, doctoral degree recipients) and single disciplines (e.g., nanotechnology, biochemistry). This paper answers the USPTO call and fills a gap in the literature by providing a global analysis of women in patents from 1976 to 2013.

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Methods

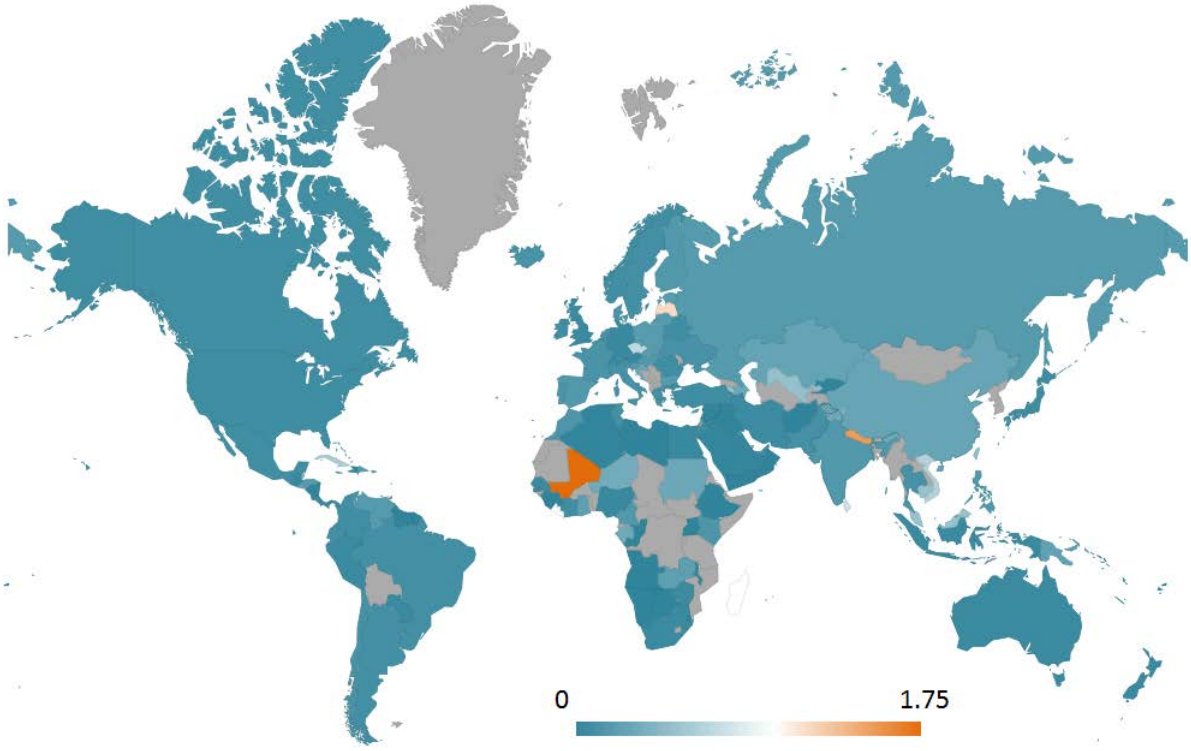
Data was downloaded from the USPTO database and transformed into an SQL relational database. The gender of inventors was categorized using first names, which was matched with worldwide and country-specific name lists, as developed in previous work (Larivière et al., 2013). 87% of 11.7 million inventorships analysed were assigned to a gender. Nationality of the assignees was listed in the patent and was used to identify fractionalized counts of patents per country.

The number of patents for female and male inventors was calculated based on fractionalized counting of patents (see Larivière et al., 2013). That is, each inventor is given 1/x count of the inventorship where *x* represents the number of inventors for which a gender could be assigned on the given patent. Therefore, if there are 5 inventors listed in a patent, 2 of them were identified as female and 3 of them as male, then the female fractionalized count is 2/5, and the male fractionalized count is 3/5.

Findings

We first sought to examine the proportion of female inventorships by country. Women contributed less than 8% of all patent authorships for the entire period (1976-2013). In 2013, women contributed to slightly more than 10% of patents. Figure 1 displays the ratio between female and male productivity in terms of patenting (with fractionalized counts). As demonstrated, men dominate production in nearly every country (in 42 countries, there are no female inventors). Five countries are female dominated; however, these all have fewer than 35 fractionalized patents (Mali, Nepal, Latvia, Madagascar, and Liberia).

Figure 1: Female to Male Productivity Ratio by Country



Ten countries make up more than 90% of the world share of patents. These countries, and associated female-male ratios and fractionalized inventorship counts are provided in Table 1.

Table 1. FMRatio in top 10 countries by number of patents (93.6% of the world total)

Country	FMRatio	Fractionalized count
United States	0.07	2,349,090.00
Japan	0.07	850,786.10
Germany	0.04	311,242.40
United Kingdom	0.05	114,264.80
France	0.12	106,867.80
Republic of Korea	0.16	97,578.94
Taiwan	0.47	95,741.60
Canada	0.08	90,578.42
Italy	0.11	47,412.98
Switzerland	0.04	46,708.73

As shown, Germany, the United Kingdom and Switzerland have the lowest levels of parity; whereas Taiwan is closest to parity (followed by Korea). We further investigated male dominance in terms of those countries producing more than 1,000 patents (Table 2), with Austria, Germany, Switzerland and the UK having the most extreme male dominance.

Table 2. Countries with highest male dominance (more than 1,000 patents)

Country	F	M	FMRatio	TotalN
Austria	3.14%	96.86%	0.03	15,924.24
Germany	3.91%	96.09%	0.04	311,242.4
Switzerland	3.96%	96.04%	0.04	46,708.73
United Kingdom	4.50%	95.50%	0.05	114,264.8
Australia	4.97%	95.03%	0.05	25,616.45
South Africa	4.47%	95.53%	0.05	3426.379
New Zealand	5.17%	94.83%	0.05	3197.525
United States	6.57%	93.43%	0.07	2,349,090
Japan	6.74%	93.26%	0.07	850,786.1
Canada	7.16%	92.84%	0.08	90,578.42

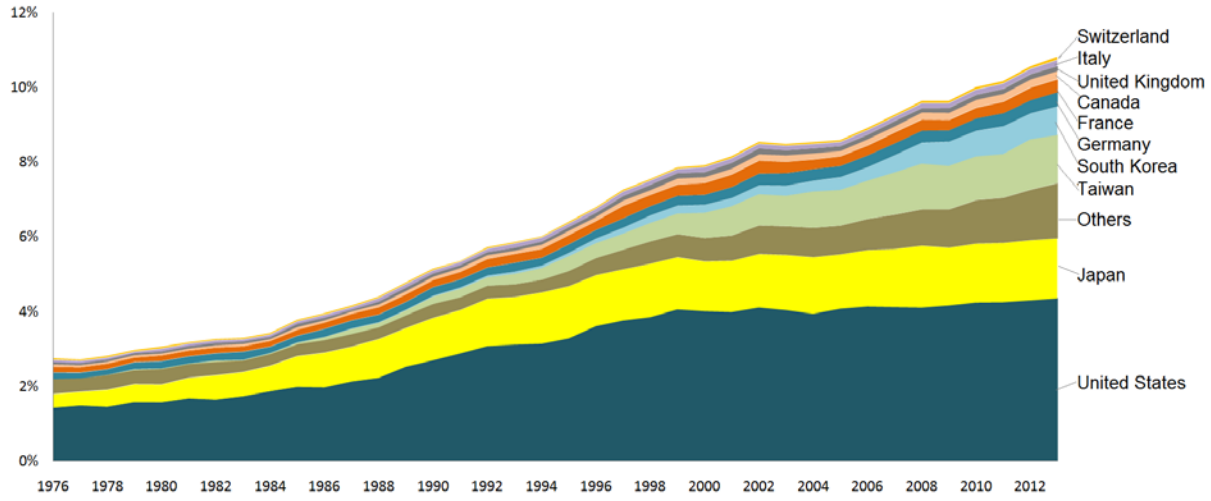
Few countries come close to parity. Table 3 ranks, by gender partiy, countries that have more than 1,000 patents. As shown, Asian countries and the USSR/Russia come closest to parity, though men are still dominant.

Table 3. Countries coming closest to achieving parity

Country	F	M	FMRatio	TotalN
Malaysia	33.91%	66.09%	0.51	1544.403
Taiwan	32.13%	67.87%	0.47	95,741.6
Singapore	21.42%	78.58%	0.27	6401.447
China	20.94%	79.06%	0.26	23,713.66
Poland	15.63%	84.37%	0.19	1044.417
Union of Soviet Socialist Republics	15.56%	84.44%	0.18	4219.982
Russian Federation	15.56%	84.44%	0.18	4198.689
Korea, Republic of	13.60%	86.40%	0.16	97,578.94
Israel	13.77%	86.23%	0.16	24,789.74
Finland	14.02%	85.98%	0.16	16,999.29

Figure 2 displays the ten countries contributing most to the total share of female patents over time. As is shown, Taiwan and Korea have seen large increases in their overall contribution to female patenting since the mid-1990s. The proportional contribution to female patenting from the United States and Japan has remained fairly stable since 2000.

Figure 2: Top 10 countries' (by number of patents) contribution to global female patenting



Work-in-progress

While we have provided an overview of the global statistics, we also need to analyse the contribution of women to different areas of patenting and the contexts in which this patenting occurs. For example, it has been suggested that women are more risk averse and the lack the social networks necessary to effectively commercialize their work (e.g., Abreau & Grinevich, 2013). However, others have suggested that institutional setting and resource allocation, rather than personal proclivities, are better predictors of potential patenting (e.g., Colyvas, Snellman, Bercovitz, & Feldman, 2012). It may also be that women are concentrated in fields or countries where patenting is either discouraged or less incentivized.

One thing that remains constant is women's patenting remains lower than would be predicted given their representation in science, technology, engineering, and mathematics fields and

professions (Mauleon & Bordons, 2010) and their relative productivity in publishing (Larivière et al., 2013). More work needs to be done to understand why this valuable human resource is not being captured in the innovation process and mechanisms that can be used to support full participation of the scientific workforce in patenting activities and how this relates to other types of gender disparities. However, for richer analyses, triangulating data from qualitative and quantitative sources may be necessary. This may be particularly useful in understanding why, for instance, women's names are included on publications related to a patent, by disappear between the articles about the patents and the patents themselves (Lisson, Montobbio, & Zirulia, 2013). Using country-level data is only an initial step in investigating the types of environments and policies that are more conducive to gender parity.

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