DOES WORKING WOMEN'S CAUSES INNOVATION: AN UNTOUCHED REALITY?

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Abstract: *Working women play a vital role in all fields of lifestyle and are the pillars of society. Women's workforce is the key to economic boom, innovation, research and development, growth and prosperity in modern societies. Globally, governments spend billions of dollars to promote the workforce, to enhance their country's economy and innovation. This research aims to contribute to the knowledge on innovation by working women globally and to investigate how working women affect the process of innovation, using the number of patents and trademarks as innovation indicators. The empirical study adopted a two-stage least squares (2SLS) estimation and generalized method of moments (GMM) with and without robust standard errors. Panel data of 136 countries for the period 1996–2016 was used. The results of this study show that working women positively and statistically significantly explained the patent and trademark, which is a proxy for innovation with other control variables (per capita income, education, research and development, technology, article, industry, and foreign direct investment). Overall, the findings show that working women have a positive effect on innovation – they exert a positive and significant effect on patents and trademarks. The regression results based on GMM and system GMM (SGMM) show how working women influence trademarks and patents. Specifically, the GMM reveals that the regression coefficients of patent and trademark positively affect innovation, with all variables being positive at the 1% level, indicating that the current level of patent and trademark is positive. This implies that working women have favourable economic participation in innovation. This study contributes to the cross-over of knowledge on innovation and working women and reduces the existing scarcity of information on the subject.*

Keywords: *Working women, innovation, patent, trademark, GMM.*

JEL Classification: *J24, O31, I25, C33.*

APA Style Citation: Jun, W., Jamil, I., Mughal, B., Waheed, J., & Hussain, H. (2020). Does Working Women's Causes Innovation: An Untouched Reality? *E&M Economics and Management, 23*(4), 102–118. https://doi.org/10.15240/tul/001/2020-4-007

Introduction

Human asset training and development increases the productivity and skills of workers (Saif et al., 2019). Globally, governments spend billions of dollars to promote the workforce, to enhance their country's economy and innovation. Working women are the pillars of society and play a vital role in its development. The female workforce is the key to innovation, growth, and prosperity in modern societies. Globally, economists focus on the practical and theoretical side of how working women perform an active role within the workforce and how they positively contribute to growth and innovation (Luci, 2009).

Women first started participating in the workforce during the late 19th and early 20th century. Worldwide, owing to higher per capita economic growth, the demand for female participation in the labour force has been increasing and motivating the working women to participate in development and innovation activities. Women's participation in the labour force enhances their lifestyle and increases their economic status. In developing countries, the contribution of women has been continuously increasing and plays a vital role in academic development and innovation (Shami et al., 2019; Klasen, 2019).

Working Women and Education

Talent is the most precious resource in today's knowledge-based economy. Specifically, education promotes achievement among young girls and women, while also fostering overall innovation and economic development. Education is essential for development in all aspects of life (Subramanian, 2007; Mendy, 2008; Ombonga, 2008). Worldwide, ensuring the education of women is the most effective way to improve their lifestyle (Elson, 1993). The skilled women with resources have positive consequences for the improvement of human capital (Chant, 2005; Smyth, 2007). Such consequences advise a strong instrumental reason for ensuring women's contribution to innovation and development practices. Education as well as educational counselling is essential for making the women economically independent and self-reliant. It helps the women to become self-aware and to acknowledge their strengths, weaknesses, and capabilities. The neoclassical theory also posits that the education of a girl causes further growth as individuals and professionals development. Higher education among women means more participation in innovation.

Encouraging Factors That Motivate Women towards Education

The factors that encourage working women, education, development, achievement, and innovation, the vital role is gender importance. Many studies have represented gender-based to analyse the contribution of women in patent applications, and innovative activity (Chatterjee & Ramu, 2018) Studies have also explained and found that women's participation in development, R&D, and innovation activities is increasing, there still exist significant gaps earlier than women can wish to acquire parity with innovation. Many scholars have already produced significant research that illuminates women's contributions to technological improvements and their commercialization across time and place. However, many previous researchers discount the relationship between working women and innovation. This research addresses the contribution of working women (or lack of it) patents and trademark are significant indicators of innovation.

Working Women and Their Contribution to Economic and Social Development

Economically, social development depends censoriously on the contributions of women's productivity (Khan, 2015). According to the women's bureau report, the growth of women is increased by almost 51% of the total labour force during the year of 2008 to 2018, (Richardson et al., 2018). The International Labour Organization (ILO) reports that, in 2018, the average worldwide labour force participation rate of women stood at 48.5%. Working women have to achieve self-confidence, skills, and information that they need to be better workers and naturalized citizens. Working women might have a chance at a healthier and happier life. Moreover, there are significant benefits to the society at large.

Currently, global work is going to change with women at work and innovation that provides a more significant proportion of the total workforce. In many developed parts of the world, women support and improve technology and business (Padnos, 2010). Women's impact on SMEs has the potential to inspire national economic and innovative growth and show a positive and significant direct relationship between social capital and innovative capability with firms (Jafri et al., 2014). Notability shows that predominantly working women and young girls perform well in the fields of scientific research education, business organization, firm innovation, financial performance, entrepreneurship, growth, labour market, innovation, and research and development (Jun et al., 2020; Wang et al., 2019; Blickenstaff, 2005; Dafna Kariv, 2010; Wynarczyk, 2013; Hughes et al., 2012; Chatterjee & Ramu, 2018; Rodriguez & Pillai, 2019).

Women directors contribute insistently and significantly to organizational innovation (Torchia et al., 2018). Women are a significant force in entrepreneurial activities, as entrepreneurs and innovators are successful positive factors for women's entrepreneurial innovations (Bulsara et al., 2014; Kemppainen, 2019). Labour market participation has a positive and significant impact on growth (Luci, 2009). In a firm's innovation, female managers are expected to introduce and perform innovations (Dohse et al., 2019).

Women executives in firms that have more power are more likely to increase firm policies and intensive advertising, such as R&D and innovation (Adhikari et al., 2019). In Britain, France, and the United States, industrial fairs and prize-granting institutions had women patentees who were significantly more likely than men to be associated with innovations in art and technology (Khan, 2017). In the short – and long-term economic impact of mass migration, gender has influenced positively, and immigrant women have also formed a positive economic development (Berlepsch et al., 2019).

Working Women and Innovation

Innovation is a vital key for development and manufacturing, and is now an excellent area for technological advancement that provides new opportunities for women's involvement in innovation. Women have stronger positions and new improvements to generate innovations through their scientific research. Innovation is the engine of economic boom, and many researchers and economists are interested in analysing the economic growth of the main determinants, such as R&D expenditure (Savrul & Incekara, 2015; Zhang & Tang, 2017), international trade and investment (Doruk, 2016; Chu et al., 2018), and financial development (Hsu et al., 2014) socio-cultural forces have been proven to be vital factors affecting innovation (Coccia, 2014; Gao et al., 2017; Kostis et al., 2018). This argument is mainly based on the understanding that invention and creation always occur in a particular social and cultural environment (Srinivas & Sutz, 2008), which significantly influences the channel and performance of innovation.

Many studies related to working women have been presented in literature, which usually discussed the role of working women in patent applications related to technology and innovation, as innovation is a proxy for patents and trademarks. However, there is a lack of discussion in the literature about the participation of working women related to trademarks that will ultimately enhance innovation. In order to enhance the study related to the role of working women in economic and social development, hypotheses have been developed in the next section by considering the limitations present in previous studies.

Hypotheses Development

We hypothesize the following:

H1: Working women have a positive impact on innovation (Patent and Trademark).

Patent and trademark activities represent work as a vital element for the improvement of industrial development and innovation. Working women play a significant role in innovation and patenting. Patenting, however, is a significant measure of innovation. Women's participation in information technology (IT) patenting is essential for innovation and development (Ashcraft & Breitzman, 2012). However, numerous studies explain that working women and young girls continue to be represented in development, economic boom, labour marketplace, entrepreneurship, research and development, and innovation activity (Blickenstaff, 2005; Wynarczyk, 2013). Around the globe, work is shifting with the participation of working women and contributing a substantial percentage to the total workforce. Working women are now in a stronger position to create new ideas, development, technology, and innovations with the help of R&D and scientific research. A patent represents a specific invention and is correlated with different innovations. Technological progress, innovation, economic boom, financial growth, and new ideas; many researchers utilize patents as a proxy (Hunt et al., 2012).

Trademark is intrinsically related to a brand new, modern application of innovation, and as an instrument for structural modification inside the financial system. The rational and empirical grounds trademarks use as indicators in innovation (Schmoch, 2003).

Trademark application is a proxy of innovation and used for technology change. In social sciences, trademark is used by a brand to increase the firm's ability, economic returns, and new products. The application of trademarks can be used to measure innovation in emerging streams of research (Greenhalgh & Rogers, 2012). The application of trademarks contributes to creating the innovative output of profit-oriented firms. The trademark indicator is to use and measure the traditional innovative activity and innovation (Mendonça et al., 2004), trademarks can contribute to innovation and the process of industrial change and can be suggested that trademarks are complementary indicators in practical tools of innovation studies and industrial and business dynamics.

We fail to find an exact study that will link working women participation related to trademark that will ultimately enhance innovation. Hence the motive of the current study is to fill the gap in this aspect under the shade of data gathered from 136 countries around the globe.

1. Econometric Methodology, Model and Data

1.1 Data and Variable

Panel data collection is more excellent and luxurious as compared to the collection of time series or cross-sectional data. Panel data are broadly available in both developed and developing countries. World Development Indicators (WDI) are composed of patent and trademark applications total, labour force total, employment to population ratio, GDP, GDP per capita, R&D, technicians in research and development (per million people), scientific and technical journal articles, industry, value added (% of GDP), employment to population ratio, 15+, female (%), FDI, GINI, and CPI. Because the data is available only from 1996 to 2016, the sample used in this study is limited to said time interval.

1.2 Sample Size

Using annual panel data, we encompass 136 countries from 1996 to 2016. Ensuing the classic studies on innovation application (Lau et al., 2015), in our study, the approach of panel data was published in the first edition of Hsiao's in 1986. Panel data contains more advantages than cross-sectional data (Wooldridge, 2015). First, panel data increases and improves the accuracy of estimations. Second, panel data provides the individual's dynamic performance. Finally, the missing variable can be resolved with the help of panel data. To deal with endogeneity problems and to find the instrument variables, we utilize the technique of panel GMM as the primary regression using lagged dependent variables.

1.3 Dependent Variable

The current empirical literature mainly utilizes patent statistics (e.g. patent application or grant counts) to quantify innovation performance. Compared to other indicators, patent statistics have several unique advantages (Griliches, 1990; OECD, 2009; Nagaoka et al., 2010); patents have very close links to inventions, and patent documents contain detailed industrial, organizational, and technological information on innovation. Patents and trademarks are also recognized as valid indicators of innovation, and enterprises often combine them with patents to achieve significant economic benefits and development (Flikkema et al., 2019; Seip et al., 2018). The increase in new technologies, patents, and trademarks are also very active indicators that the government employs to boost the country's development and R&D (Samara et al., 2012; Pradhan et al., 2018). Consequently, the application of patents and trademarks is commonly applied as a proxy for innovation (Lau et al., 2015; Roper & Hewitt-Dundas, 2015). In this study, we use patent and trademark application counts as proxies for a country's innovation performance of working women, denoted by patent and trademark.

1.4 Control Variable

In this study, we employ the following macroeconomic and institutional control variables related to innovation performance at country level.

1.5 R&D (Research and Development) Expenditure on GDP Intensity

R&D intensity is used to measure the ratio of R&D expenditure to GDP and is denoted by R&D. R&D intensity is considered to be a critical factor in innovation performance (Savrul & Incekara, 2015; Zhang & Tang, 2017). The innovation level is fantastically associated with R&D expenditure, and more significant expenditure may additionally cause higher patent and trademark applications. We expect that R&D has a significant and positive effect on the level of innovation activity.

1.6 GDP per Capita

GDP per capita is measured as the ratio between gross domestic product and mid-year population and is denoted by GDP. As an indicator of a country's economic development, GDP is believed to contribute to better innovation performance (Raghupathi & Raghupathi, 2017). As per a famed researcher, overall performance exists due to the association between growth and activity of innovation (Arin et al., 2011; Kogan et al., 2017). We additionally use per capita GDP as a control variable in our study for better economic performance.

1.7 Employment to Population Ratio (Education)

Employment to population ratio is measured by the ratio of total enrolment to the population of the age group that officially relates to education level and is denoted by education. Education promotes human knowledge, skills, and growth; it will increase the availability and the potential to grasp the know-how, understand, improve, and enhance knowledge (Roper et al., 2017). As a measure of a country's scientific literacy and human capital (Cheung et al., 2012), we suppose that education has a positive effect on the application of innovation.

1.8 Foreign Direct Investment, Net Inflows

FDI offers more excellent assets, economic development, and R&D and also provides funds to the host country. FDI can enhance innovation activity in the host country by including professional productivity of labour, engineering, and work mobility (Cheung & Lin, 2004; Khachoo et al., 2018). Significantly, FDI provides a technology that has positive effects on development (Song et al., 2015; Perri & Peruffo, 2016). The main purpose of FDI is to provide cheap labour force (Belloumi, 2014). We expect that net inflows of FDI to GDP in our study have a positive effect on innovation.

1.9 Scientific and Technical Journal Articles

Economically, development, innovation, education, information, and expertise are the primary keys of technical development (Godinho et al., 2008). Additionally, scientific research is significantly related to the application of innovation and scientific knowledge. Education, innovation, training, and achievements are shown in the form of research articles and enhancing innovation and technological progress. Therefore, using articles and research as a proxy of knowledge (Gastel & Day, 2016), we expect that the articles have a significant effect on innovation.

1.10 Industry Value Added (% of GDP)

The industrial organization has a positive effect on innovation (Frias et al., 2012). Industrial renewal and innovation are broadly considered a cure for stationary economic boom, unemployment, and other social challenges (Kander et al., 2019). In an energy-intensive industry, innovation also has a positive effect (Song & Oh, 2015). In our study, we suppose that the control variable of industry also has a positive effect on patent and trademark applications, which are proxies for innovation.

1.11 Total Labour Force (TLF)

Labour force is the backbone for innovation all around the world. The share of the labour force is positively involved in R&D and firm size in high-tech group of firms. (Shefer & Frenkel, 2005). Labour force will increase communication inside the labour pool, which may additionally create new thoughts and inspiration, new technology, and innovation (Dong & Martin, 2017). We suppose that the labour force also has a direct and indirect significant effect on innovation.

1.12 Employment to Population Ratio, Female (WW)

The main independent variable in our research was working women. Working women play a vital role in innovation. In the last century, the rising female labour force participation has been one of the most outstanding economic developments. In recent years, the increasing rate of women's labour force has greatly increased the development of the labour market development (Korotayev et al., 2015). According to ILO, there are almost 74.6 million women in the labour force and 10 million in business activity worldwide. Women are estimated to have had almost a 51% increase in total labour force growth during 2008–2018 (International Labour Office, 2018). In the last few decades, the Middle East and North Africa (MENA) have analysed and enhanced women's well-being and also provided women's economic opportunities and employment rates

(Fakih & Ghazalian, 2015). Many studies explain and find that women's participation in development, R&D, and innovation level is increasing; there still exist significant gaps earlier and women can wish to acquire parity with innovation. We assume that working women have a significant and positive impact on trademark and patent applications, which are the proxies of innovation.

1.13 Econometric Modelling Setup

The following is the general structure of the simultaneous formula model for patents and trademark, which is the proxy of innovation.

$$\text{Patent} = y_1 = \alpha_1 + \beta_{1i}X + \theta_1 R\&D + \varepsilon_{1t}$$

$$\text{Trademark} = y_2 = \alpha_{12} + \beta_{12i}Z + \theta_{12}R\&D + \varepsilon_{2t}$$

where X and Z are the vectors of the control variables in both formulas. After solving the reduced form of the simultaneous formula:

$$y_i = \left\{\frac{(\alpha_1\theta_{12} - \alpha_{12}\theta_1) + \theta_{12}\beta_1 X - \theta_1\beta_{12}Z - \theta_1\lambda_{12}y_{t-i} + (\theta_{12}\varepsilon_{1t} - \theta_1\varepsilon_{2t})}{\theta_{12} - \theta_1}\right\}$$

$$R\&D_i = \left\{\frac{(\alpha_1 - \alpha_{12}) + \beta_1 X - \beta_{12}Z - \lambda_{12}y_{t-i} + (\varepsilon_{1t} - \varepsilon_{2t})}{\theta_{12} - \theta_1}\right\}$$

1.14 Instrumental Variable Method

The assumption of the regression analysis based on the independence of the error term is uncorrelated with the independent variables. However, in the case of a large data set, the assumption of independent error terms violated and estimated becomes inconsistent and biased. Therefore, the instrumental method is the best way to overcome endogeneity problems.

1.15 Model Specification

The general structure of the model with instrumental regression analysis is used to estimate the dynamics of innovation and working women with other control variables.

$$\text{Innovation} = \beta_1 \text{Working women} + \beta_x X_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (1)$$

where Innovation includes patent and trademark; Working women is an independent variable; *X* is a vector of macroeconomic and institutional control variables, including GDP, education, R&D, technology, article, industry, and FDI; μ_i and μ_t represent the unobserved country-specific effects and time-specific effects, respectively; ε_{it} is the random disturbance; i and t denote country and year, respectively.

$$\ln I_{it} = \alpha_1 \ln I_{it-1} + \beta_1 \ln WW_{it} + \beta_x X_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (2)$$

Taking the log on both sides of the formula *lnI* is the log of innovation, while is the log of working women while represents the lagged term of Innovation_{it}; and explanations of the remaining notations in Formula (1) are the same as in Formula (2):

$$\ln Pat_{it} = \alpha_0 + \beta_1 \ln WW_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln Edu_{it} + \beta_4 \ln R\&D_{it} + \beta_5 \ln Tech_{it} + \beta_6 \ln Art_{it} + \beta_7 \ln Ind_{it} + \beta_8 \ln FDI_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (3)$$

$$\ln TM_{it} = \alpha_0 + \beta_1 \ln WW_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln Edu_{it} + \beta_4 \ln R\&D_{it} + \beta_5 \ln Tech_{it} + \beta_6 \ln Art_{it} + \beta_7 \ln Ind_{it} + \beta_8 \ln FDI_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (4)$$

We calculate innovation as patent and trademark, so we make a separate model of patent and trademark, the above formula Pat_{it} is the total number of patents, WW_{it} is the total number of working women, Edu_{it} is the percentage of education, GDP_{it} is the ratio of gross domestic product, is he ratio of R&D expenditure, $Tech_{it}$ is the percentage of technology, Art_{it} is the total number of articles, Ind_{it} is the total number of industries, FDI_{it} and is the percentage of foreign direct investment. The above formulas represent country i at time t, β_n is the patent, and β'_n represent the trademark (n = 1…..8).

For further estimation, we use the system GMM including the lag term of the dependent variables.

$$\ln Pat_{it}=\alpha_0+\beta_0 \ln Pat_{it-1}+\beta_1 \ln WW_{it}+ +\beta_2 \ln GDP_{it}+\beta_3 \ln Edu_{\ it}+\beta_4 \ln R\&D_{it}+ +\beta_5 \ln Tech_{it}+\beta_6 \ln Art_{it}+\beta_7 \ln Ind_{it}+ +\beta_8 \ln FDI_{it}+ \quad (5)$$

$$\ln TM_{it}=\alpha_0+\beta_0 \ln TM_{it-1}+\beta_1 \ln WW_{it}+ +\beta_2 \ln GDP_{it}+\beta_3 \ln Edu_{\ it}+\beta_4 \ln R\&D_{it}+ +\beta_5 \ln Tech_{it}+\beta_6 \ln Art_{it}+\beta_7 \ln Ind_{it}+ +\beta_8 \ln FDI_{it}+\varepsilon_{it} \quad (6)$$

1.16 Arellano-Bond Dynamic Panel Data Estimation (GMM)

To empirically estimate the dynamic relationship between working women's and innovation study used the Arellano-Bond dynamic panel GMM estimation technique initially presented by Arellano-Bond (1991), while further extended by the (Arellano & Bover, 1995; Blundell & Bond, 1998). The GMM is the extension of the method of the moment. So, for the estimation of GMM, first we need to estimate the moment conditions to know a vector-valued function $g(\ln I, \lambda)$.

$$m(\lambda_0 \cong E[g(\ln I_t, \lambda_0)] = 0 \quad (7)$$

According to the property of GMM technique, $\lambda \neq \lambda$, otherwise the parameter should not be identified which is λ and in our study innovation is the outcome variable.

The basic idea is the simple average:

$$\hat{m}(\lambda) \cong \frac{1}{n}\sum_{n-1}^{n} g(\ln I_t,\ \lambda) \quad (8)$$

GMM technique minimizes the expression concerning λ and λ is the estimate for λ_0. The outcome estimator will depend on the particular choice of the norm function, defined as:

$$\| \hat{m}(\lambda) \|_W^2 = \hat{m}(\lambda)^n W \hat{m}(\lambda) \quad (9)$$

where W is the weighted matrix and results on the bases of the on hand dataset. Thus, the GMM estimator can be written as:

$$\hat{\lambda} = \arg min \left(\frac{1}{n}\sum_{n-1}^{n} g(\ln I_t,\ \lambda)\right)^n \hat{W}\left(\frac{1}{n}\sum_{n-1}^{n} g(\ln I_t,\ \lambda)\right) \quad (10)$$

Formula (10) shows that the above estimator of the GMM is identical, consistent, asymptotically normal and efficient.

2. Results and Discussions

To estimate the empirical relationship between working women and innovation articles, the panel 2SLS, GMM, system GMM, robust GMM, and robust system GMM methodology is used with various panel pre- and post-estimation tests. The results of the research study investigated the relationship between working women and innovation through descriptive statistics, correlation matrix, and performed pre-estimation test, heteroscedasticity, autocorrelation, and endogeneity tests. Tab. 2 and Tab. 3 present the descriptive statistics and correlation matrix results. While Tab. 3 presents the 2SLS, Tab. 4 presents the GMM, system GMM, and Tab. 5 presents robust GMM and robust system GMM results to estimate the empirical relationship between working women and innovation. To investigate the heteroscedasticity, study used the modified Wald test for the group. The estimated results of the modified test reported that we could reject the hypothesis of heteroscedasticity in the panel of 136 countries. To investigate the autocorrelation problem in the panel data study, the Wooldridge autocorrelation test was used for panel data. The estimated results of the Wooldridge autocorrelation test showed that we could reject the hypothesis of autocorrelation in the panel of 136 countries to estimate the empirical relationship between working women and innovation.

2.1 Explanation of Tables

Tab. 1 lists the descriptive statistics of the variables. All data were transformed into their natural logarithms. The main variable statistics summary includes the number of observations, standard deviation SD, mean, and the maximum and minimum values of the variables that exist in this research. In Tab. 1, the mean and maximum values are 17,514.8 and 1,338,503, respectively, while the minimum value of the patent application is 0, indicating there is significant disparity in patent applications among the sample countries. The disparity is relatively less severe when it comes to trademark. The minimum, maximum, and mean values are 1, 2,104,409, and 25,064.6, respectively. We conclude that the distributions of patent and trademark standard deviations are relatively more significant, and after comparing the total mean values of patent and trademark, we find that the mean of trademark is higher than that of patent, meaning that working women are the better performers in innovation. It is well observed that the mean value of patent is higher than the median value of patent, meaning that more than 50% of innovation in countries is smaller than the average level. The mean, maximum, and minimum values of working women are 46.28399, 86.0122, and 4.494, respectively, while 15.65538 is the standard deviation. The minimum, maximum, and mean of the R&D are 0.00544, 4.42859, and 1.087494, respectively while 0.9637958, is the standard deviation. The minimum, maximum, and mean values of FDI are −58.32288, 252.3081, and 4.961405, respectively, whereas the 9.620799 is the standard deviation, which means that FDI has a significant difference among the countries. The mean value of education is 85.38392, with 25.71079 standard deviations, which means that education is least fluctuating. Therefore, in our research to estimate the model, we utilize the GMM method because, for the Heterogeneity problem, the GMM estimator is best.

Tab. 2 presents the correlation of all variables used in the study. The main diagonal of the table presents the self-association of each variable. The estimated results show that patents are 82% positively associated with trademark, while 51%, 74%, 25%, 47%, 31%, 79%, 36% and 43% correlated with working women, per capita income, education, R&D, technology, art, industry, and foreign direct investment, respectively. Trademark is positively 39%, 57%, 25%, 34%, 25%, 71%, 30% and 35% correlated with working women, per capita income, education, R&D, technology, art, industry, and foreign direct investment, respectively. Working women positively associated 39%, 57%, 25%, 34%, 25%, 71%, 30% and 35% correlated with working women, per capita income, education, R&D, technology, and FDI, respectively. While art and industry negatively correlated with working women by about 19% and 20%, respectively.

Tab. 3 lists the regression results based on 2SLS method, as how working women influence the trademark and patent, columns 1–3 describe the patent, and columns 2–4 represent the dependent variable of trademark. In both columns, the critical explanatory variables are GDP, education, R&D, technology, article, and industry. First, we checked the working women's influence on patent. In column 1, we find that the

Tab. 1: Descriptive statistics of the variables

Variable	N	Mean	SD	Min	Max
Patent	2,056	17,514.8	79,029.26	0	1,338,503
Trademark	2,496	25,064.6	89,149.58	1	2,104,409
Labor	2,751	2.140	7.83	0.34997	7.870
Working women	2,750	46.28399	15.65538	4.494	86.012
GDP per capita	2,797	5.1900	7.2600	0.8760	9.4300
Education	2,001	85.38392	25.71079	5.21012	163.9305
R&D	1,423	1.087494	0.9637958	0.00544	4.42859
Technology	919	595.0469	639.9537	0.12361	3,766.862
Article	1,854	13,727.22	46,329.9	0	440,229.7
Industry	2,699	26.97263	10.26277	2.073173	74.11302
FDI	2,679	4.961405	9.620799	−58.32288	252.3081
Female education	1,963	85.93736	27.13166	3.96602	175.2213
GNI	1,089	37.97796	9.130962	23.7	65.8
CPI	2,544	87.8612	62.82579	2.35212	2,740.274
Income per capita	2,713	4,513.726	192.00	780.744	259,000

Source: own

Note: N = Number of observations; SD = Standard Deviation; Min = Minimum; Max = Maximum; Labor in Million.

Tab. 2: Correlation matrix

Variable	1	2	3	4	5	6	7	8	9	10
	Lntp	Lntd	Lnww	Lngdp	Lnedu	Lnrd	Ln-tech	Lnart	Lnind	Lnfdi
Lntp	1.00									
Lntd	0.82	1.00								
Lnww	0.51	0.39	1.00							
Lngdp	0.74	0.57	−0.56	1.00						
Lnedu	0.25	0.25	0.02	−0.02	1.00					
Lnrd	0.47	0.34	0.16	0.24	0.50	1.00				
Lntech	0.31	0.25	0.20	0.09	0.66	0.50	1.00			
Lnart	0.79	0.71	−0.13	0.53	0.45	0.70	0.62	1.00		
Lnind	0.36	0.30	−0.20	0.39	0.10	−0.08	−0.08	0.18	1.00	
Lnfdi	0.43	0.35	0.14	−0.35	0.10	−0.11	−0.08	−0.27	−0.17	1.00

Source: own

regression coefficient of patent is 3.1429, which is positive at 1% level. This finding shows that working women have a positive and significant effect on patents. The results of column 2 regression coefficient of trademark is 1.6788, which means that working women also have a positive effect at 1% level and a significant effect on innovation performance. This implies that working women have favourable economic participation in innovation.

Tab. 3: Regression results of working women on innovation 2SLS – Part 1

Variable	1	2	3	4
	Patent	Trademark	Patent	Trademark
Working women	3.1429*** (0.8067)	1.6788*** (0.44794)	3.058*** (0.8134)	1.674*** (0.4243)
GDP	−1.7740*** (0.3599)	0.40659*** (0.19754)	−0.9872*** (−0.4396)	1.025*** (0.2209)
Education	1.0229*** (0.4128)	0.73754*** (0.21944)	1.321*** (0.4485)	1.051*** (0.2274)
R&D	0.20663** (0.12102)	−0.25951*** (0.06377)	0.3364*** (0.1288)	−0.1487*** (0.0635)
Technology	0.24981*** (0.10498)	0.10198*** (0.05738)	0.2209*** (0.1075)	0.0413 (0.05600)
Article	0.02148 (0.12075)	−0.24555*** (0.07026)	0.1709 (0.1298)	−0.03302 (0.07318)
Industry	−0.21434 (0.40271)	0.03965 (0.21471)	−0.6751 (0.4238)	−0.4534 (0.2154)
FDI	0.04264** (0.02966)	0.07284*** (0.01595)	0.0253 (0.0325)	−0.0519*** (0.0163)
Country effect	Y	Y	Y	Y
Year effect	N	N	Y	Y
Centered R^2	0.1413	0.2331	0.1872	0.3481

Tab. 3: Regression results of working women on innovation 2SLS – Part 2

Variable	1	2	3	4
	Patent	Trademark	Patent	Trademark
Uncentered R^2	0.1413	0.2331	0.1872	0.3481
Root MSE	0.3741	0.1997	0.3639	0.1841
N	339	331	339	331

Source: own

Note: Patent and Trademark here are the value of the natural logarithm of the total number of patent and trademark; Z-stat in parenthesis; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Y and N represents Yes and No, respectively.

Tab. 4: Regression results of working women on innovation GMM/SGMM

Variable	1 GMM		2 System GMM	
	Patent	Trademark	Patent	Trademark
Working women	3.1429*** (0.8067)	1.6788*** (0.44794)	1.076*** (0.5435)	0.3951*** (0.2602)
LntpLI. (IntmLI.)	–	–	0.6862*** (0.03532)	0.7283*** (0.03281)
GDP	−1.7740*** (0.35990)	0.40659** (0.19754)	−0.4156* (0.2485)	0.1210 (0.1167)
Education	1.0229*** (0.41281)	0.73754*** (0.21944)	0.1753 (0.2735)	0.3097*** (0.1293)
R&D	0.20663* (0.121028)	−0.25951*** (0.06377)	0.1448 (0.0809)	−0.0551* (0.0383)
Technology	0.24981** (0.10498)	0.10198** (0.05738)	0.0246 (0.0715)	−0.0034 (0.0339)
Article	0.02143 (0.12075)	−0.24555*** (0.07026)	0.0949 (0.0786)	−0.0677 (0.0420)
Industry	−0.21434 (0.40271)	0.03965 (0.21471)	0.1088 (0.2646)	0.10374 (0.1251)
FDI	0.04264** (0.02966)	0.07284*** (0.01595)	−0.0021 (0.01942)	0.0423*** (0.00939)
Country effect	Y	Y	Y	Y
Year effect	N	N	Y	Y
Centered R^2	0.1413	0.2331	0.6400	0.7416
Uncentered R^2	0.1413	0.2331	0.6400	0.7416
Root MSE	0.3741	0.1997	0.2429	0.1163
N	339	331	335	329
Sargan test	21.48	12.84	31.60	13.47

Source: own

Note: Patent and Trademark here are the value of the natural logarithm of the total number of patent and trademark; z-stat in parenthesis; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Y and N represents Yes and No, respectively.

Evidently, and based on GMM and SGMM, Tab. 4 presents the regression results on how working women influence patent and trademark. Column 1 we use GMM and the regression coefficients of patent is 3.1429, while the trademark 1.076, which shows that the variables are all positive at the 1% level, indicating that the current level of patent and trademark is positive. This result indicates that the working women have a positive and significant effect on patents and trademarks. This implies that working women have favourable economic participation in innovation. In our study, the effect of some other control variables on the application of innovation is also significant. For example, R&D expenditures to GDP (R&D) also have a significant effect on innovation, which means that R&D increases the innovation level. These findings provide suggestions to policymakers that R&D expenditures are improving innovation performance. The study results show that a 1% change in the lag value of working women leads to an increase of 3.1% in patent. A 1% change in working women leads to an increase of 1.6% in trademark. In Column 2, we use SGMM, and the regression coefficients of patent is 1.076, while the trademark 0.3951, which shows that lagged dependent variables are all positive at the 1% level, indicating that the current level of patent and trademark is positive. This result also indicates that the working women have a positive and significant effect on patents and trademarks. This implies that working women have favourable economic participation in innovation.

Tab. 5: Regression results of working women on innovation robust 2SLS

Variable	1	2	3	4
	Patent	Trademark	Patent	Trademark
Working women	3.1429*** (0.9758)	1.6788*** (0.5264)	1.0844** (0.5695)	0.4845** (0.2394)
GDP	−1.7740*** (0.3887)	0.40659* (0.2245)	−0.3318 (0.27948)	0.2078 (0.1315)
Education	1.0229*** (0.3645)	0.73754*** (0.2044)	0.4077** (0.19235)	0.2078 (0.1315)
R&D	0.20663 (0.17523)	−0.25951*** (0.0795)	0.17162 (0.1125)	−0.00291 (0.0455)
Technology	0.24981* (0.13781)	0.10198** (0.0592)	0.0453 (0.1026)	−0.02914 (0.0331)
Article	0.02143 (0.17112)	−0.24555*** (0.0730)	0.1362 (0.1345)	−0.0331 (0.0418)
Industry	−0.21434 (0.44325)	0.03965 (0.2040)	−0.1257 (0.31041)	−0.1003 (0.1463)
FDI	0.04264 (0.03294)	0.07284*** (0.01774)	−0.0239 (0.02062)	0.0246** (0.0132)
Country effect	Y	Y	Y	Y
Year effect	N	N	Y	Y
Centered R^2	0.1413	0.2331	0.6581	0.7909
Uncentered R^2	0.1413	0.2331	0.6581	0.7909
Root MSE	0.3741	0.1997	0.2367	0.1046
N	339	331	335	329

Source: own

Note: Patent and Trademark here are the value of the natural logarithm of the total number of patent and trademark; z-stat in parenthesis; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Y and N represents Yes and No, respectively.

Tab. 6: Regression results of working women on innovation robust GMM and system GMM

Variable	1	2	3	4
	Patent	Trademark	Patent	Trademark
Working women	3.09272*** (0.89759)	1.5074*** (0.51877)	0.9361*** (0.3555)	0.3988*** (0.1404)
LntpLI. (IntmLI.)	–	–	0.6756*** (0.0616)	0.7247*** (0.0414)
GDP	−1.75833*** (0.37266)	0.37289*** (0.22345)	−0.4596** (0.2669)	0.1147 (0.0939)
Education	1.0778*** (0.360781)	0.83371*** (0.20004)	0.2182 (0.1549)	0.324** (0.1051)
R&D	0.160352*** (0.167845)	−0.27926*** (0.07653)	0.1423 (0.1060)	−0.0433 (0.0503)
Technology	0.25654*** (0.131694)	0.11308*** (0.05751)	0.0416 (0.0863)	–0.00840 (0.03499)
Article	0.006686 (0.167845)	−0.24965*** (0.068187)	0.0774 (0.1091)	−0.0727 (0.04088)
Industry	−0.142858 (0.414325)	0.05339 (0.203780)	0.2506 (0.2272)	0.1088 (0.13442)
FDI	0.039391 (0.029459)	0.06379 *** (0.017064)	−0.0105 (0.0181)	0.0453 (0.0111)
Country effect	Y	Y	Y	Y
Year effect	N	N	Y	Y
Centered R^2	0.1412	0.2434	0.6383	0.7413
Uncentered R^2	0.1412	0.2434	0.6383	0.7413
Root MSE	0.3741	0.1983	0.2435	0.1163
N	339	331	335	329

Source: own

Note: Patent and Trademark here are the value of the natural logarithm of the total number of patent and trademark; z-stat in parenthesis; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Y and N represents Yes and No, respectively.

To check the dependent variables in our model, to check the validity of our used instruments, we applied the Sargan test of over-identification. According to the literature, the instrumental variable should not be correlated with the residual. The outcomes of the Sargan test indicate that the null hypothesis is rejected, so it is clear that over-identification restrictions are valid. The results specify that instrumental variables are efficiently placed and are uncorrelated with the error term.

Tab. 5 reports the dynamic results of robust 2SLS that investigates how working women influence trademark and patent. The estimated empirical results of robust 2SLS showed that working women significantly explained patent rights and trademarks, which is a proxy for innovation. The estimated results of Tab. 5 also support the empirical results of Tab. 3, 2SLS, without robust 2SLS. From column 1, we find that the coefficient of patent is 3.1429, which is significant at 1% level. The results show that working women have a positive and significant effect on patents. The results of column 2 trademark coeffcient is 1.6788, which means that working women also have a positive and significant effect on innovation performance. This implies that working women have favourable economic participation in innovation.

Tab. 6 illustrates the dynamic results of the robust GMM and robust system GMM that investigates how working women influence trademark and patent. The estimated empirical results of robust GMM and robust system GMM showed that working women significantly explained patent rights and trademarks, which is a proxy for innovation. The estimated results of Tab. 6 also support the empirical results of Tab. 4, robust GMM, and robust system GMM without robust GMM and system GMM.

Conclusion

Using panel data covering 136 countries over the period 1996–2016, this paper examines the impact of working women on innovation via panel 2SLS, GMM, and system GMM with and without robust standard error. This study further investigated the effects of per capita income, education, R&D, technology, art, industry, and foreign direct investment on patents and trademarks, which is the proxy of innovation. To guarantee the robustness of empirical results, the study also explores the impact of working women on innovation inputs.

The main findings of this study are as follows. First, we present some pre-estimation test results, which included the modified Wald test for heteroscedasticity, the Wooldridge test of autocorrelation for panel data, and to deal with potential endogeneity problems and finding instrument variables. We employ panel 2SLS, GMM, and panel system GMM technique as the primary regression tool using lagged dependent variables. The empirical results of this study show that working women positively and statistically significantly explained the patent and trademark, which is a proxy for innovation with other control variables (per capita income, education, R&D, technology, art, industry, and foreign direct investment). The estimated empirical results of 2SLS supported the empirical results of 2SLS robust standard error. Subsequently, the GMM and system GMM estimated results supported the empirical results of robust GMM and robust system GMM and showed that working women significantly explained patent rights and trademarks. In our study, the effect of some other control variables on the application of innovation is also significant. For example, R&D expenditures to GDP (R&D) also have a significant effect on innovation, which means that R&D increases the innovation level. These findings provide suggestions to policymakers that R&D expenditures are improving innovation performance. The study results show that a 1% change in the lag value of working women leads to an increase of 3.1% in patent. A 1% change in working women lead to an increase of 1.6% in trademark. We use SGMM, and the regression coefficients of patent and trademark, which show that lagged dependent variables are all positive at 1% level, indicating that the current level of patent and trademark is positive. This result also indicates that working women have a positive and significant effect on patents and trademarks. This implies that working women have favourable economic participation in innovation. To check the dependent variables in our model and the validity of our instruments, we applied the Sargan test of over-identification. According to the literature, the instrumental variable should not be correlated with the residual. The outcomes of the Sargan test indicate that the null hypothesis is rejected, so it is clear that over-identification restrictions are valid. The results specify that instrumental variables are efficiently placed and are uncorrelated with the error term.

Acknowledgment: *Ihsan Jamil (corresponding author) acknowledges the support for this research work provided by Professor Wen-Jun, School of Economics and Finance, Xi'an Jiaotong University, China. The Financial Support is given by National Science Foundation of People's Republic of China (Grant number 71673216).*

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