Innovation in women-led firms: an empirical analysis

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Innovation in Women-led Firms: An Empirical Analysis

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Abstract

We investigate how a pervasive and arbitrary type of institutional environment as well as access to resources is associated with different levels of innovative activity between women and men-led firms. We hypothesize that women-led firms will be more innovative in the pervasive institutional environment, when uncertainty is low. On the contrary, women-led firms are likely to exhibit less innovative activity in the arbitrary institutional environment, when uncertainty is high. The relationship between a country's fiscal freedom, firm lifecycle and innovation in women -led firms is also explained.

Using micro-level cross-country data of 12,412 firms as well as a reduced sample of 5,052 firms during 2008-2015 and across 75 economies, we find that the difference in risk perception between females and males is unlikely to explain differences in innovative activity in women-led firms. Instead, availability of resources proxied by a country's fiscal freedom and availability of internal resources is positively associated with innovation in women-led firms compared to men-led firms. In developing economies, female managers are more vulnerable and fiscal freedom helps to provide a safety net and reduce innovation costs. The bottom line is that the embeddedness in a natural institutional environment and availability of resources for innovation rather than gender differences is paramount for innovation in women-led firms.

Keywords: institutions, innovation, fiscal freedom, risk, female manager, corruption
JEL: L25, J16, O31, O32

1. Introduction

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It has been long observed that innovation is often gender biased (Thursby and Thursby, 2005; Ding, Murray and Stuart, 2006; Gicheva and Link, 2015). The empirical evidence is consistent with the general perception that women are less innovative than men (Nählinder, 2010). However, this is not the case when we look at the data. The world bank enterprise survey for developing countries reports for the period of 2007-2014, there were 19.86 percent of women-led firms that created new to market products, whereas only 14.60 percent of firms which are men-led reported innovative activity (World Bank, 2015). Recent research for the United States has also demonstrated that the Phase II Small Business Innovation Research (SBIR) research-funded projects had a greater probability of being commercialized in female-owned firms than in male-owned firms (Bednar, Gicheva and Link, 2019)

Despite this non-obvious empirical fact, there is a paucity of empirical research on the gender differences in innovation (Dohse, Goel, and Nelson, 2019) and the impact of institutional change and reorganization on firm innovation (Link and Scott, 2019). Research on female entrepreneurship and innovation has become more prominent in recent years (Belitski and Desai, 2019; Balachandra et al. 2019), and has found significant differences between men and women-led firms in terms of growth ambition, firm productivity and job creation.

Similar research in the entrepreneurship and management literature has recently shifted its focus on the role of nature for female innovation and entrepreneurship (Greene, Brush, Hart and Saparito, 2001; Brush et al. 2006, 2009; Weber and Zulehner, 2010). Researchers have also found a significant funding gap between men and women ambitions entrepreneurs because of possible based biases against women (Jennings and Brush, 2013).

Literature gaps in the gender differences in innovation include an explanation as to why women are less visible as inventors, innovators or entrepreneurs than men, as well as what would be the conditions which make women take innovation risk, increase survival and growth rates (Link and Strong, 2016). Literature on entrepreneurial finance demonstrated that investors may evaluate the pitches by men more favorably than those by women (De Bruin, Brush and Welter, 2006), resulting in a lack of financial resources for women-owned firms (Gicheva and Link, 2013, 2015; World Bank, 2019). It has been argued that the investors perceive women-led firms as riskier investments than those owned by men (Greene et al., 2001). Access to finance and the nature of business culture is associated with differences in institutional environments (Estrin et al. 2013; Belitski and Desai, 2019; Bednar et al. 2019). Very little attention has been paid to women-led firms across different institutional contexts, which changes the distribution of risks of doing business and access to equity investment (Olsen and Cox, 2001; Brush et al. 2018).

Regarding the implications of this gender gap, the evidence in the literature on firm performance and innovation, survival rates and growth is mixed (Szerb et al. 2007; Brush et al. 2018). This study addresses this gap by responding to a recent call in the economics of innovation and new technology literature (Gicheva and Link, 2013, 2015; Link, 2019b) to investigate how nature - pervasive and arbitrary type of institutional environment, a country's fiscal freedom and availability of internal resources is associated with innovation between women and men-led firms.

Pervasive and arbitrary institutional environments are represented by the dominance of arbitrary or pervasive type of corruption in a country (Cuervo-Cazurra, 2006, 2008) which may change the decision making of firm managers, depending on the level of market uncertainty and manager's tolerance to risk. Our argument of using two types of institutional environment builds

on Swamy's et al. (2001) who showed using micro-data that women are less involved in bribery and may respond differently to the two types of corrupt environments. The authors called for micro-data cross-country studies to demonstrate that that corruption has less severe effects on firms led by women.

To test our hypotheses, we use two firm-level data samples for 12,412 firms and 5,052 firms across 75 developing countries during the period of 2008-2015. We find that the magnitude and direction of the effect for men and women-led firms does not depend on the level of market uncertainty and risk, associated with differences in institutional environments, but rather the extent of resources available for innovation in women-led firms. We do not find the differences in the direct effect of female management on firm innovation propensity.

This study makes several contributions. First, our work directly addresses calls for research to better understand the innovation in women-led firms (De Bruin et al. 2006; Brush et al. 2006, 2009; Gicheva and Link, 2013, 2015; Link, 2019b). Second, we contribute to the institutional and economics of innovation literatures about the channels of impact and how the level of innovation activity changes in countries with the nature of the institutional environment, fiscal freedom and availability of internal resources. We empirically test whether risk and uncertainty can explain the differences in innovation in women vs. men-led firms (Swamy et al. 2001; Verheul et al. 2006). Finally, we advance research on the understudied developing country context by using a firm-level sample, yielding cross-national insight on a larger sample of 75 countries than previous single-country studies (Nählinder, 2010; Bednar and Gicheva, 2014; Link , 2019a; Link and Scott, 2019).

The remainder of the paper is as follows. In the next section, we discuss the links between institutional context, female management, and innovation. We present our data and method in the third section, followed by results in the fourth section. Our fifth section offers discussion and conclusions.

2. Theory and hypotheses

Decisions on innovation are taken, depending on the level of risk it may impose on the execution of the decision and the likelihood of a successful outcome. Institutional environment including individual, collective and institutional trust (Webb et al. 2020), corruption and regulations (Shleifer and Vishny, 1993; Estrin et al. 2013) create conditions that can affect decision-making by changing the perception about the level of risk. This is because risk and uncertainty may directly or indirectly affect the portion of the value that can be created and captured (Baker et al., 2005). There have been several attempts to explain innovation in women-led firms both theoretically and empirically (Verheul et al. 2006; Elam and Terjesen, 2010), who explain differences in female and male entrepreneurship across countries.

First, when a firm manager makes a decision, they evaluate the level of risk, uncertainty and the likelihood of a successful outcome such as product or process innovation. If institutional environment is uncertain and risky, for example bureaucrats' action to change the frequency and amount of bribes (Fredriksson, 2014) may directly affect the predictability of a successful outcome increasing transaction, coordination and other costs. Thus, the nature as an institutional environment is important in appropriating the returns from innovation and affects costs through its hidden nature of informal institutions (Williamson, 2000; Estrin and Mickiewicz, 2011; Belitski et al., 2016). Concerning institutions, one should initially consider as gender-specific

determinants of innovation behavior (e.g. attitude to risk, tolerance to uncertainty, social-focus, morale, opportunism, etc.). According to North (1990), firm's manager will adapt her or his decision-making to the opportunities provided by institutional environment and its personal beliefs and motivation. Formal and informal rules may be established to reduce transaction costs (Williamson, 2000), but are also likely to affect decision-making.

Second, when a firm manager makes decision, he or she has a different risk preferences and tolerance to innovation uncertainty. It has been debated that women, by virtue of their sex, are fundamentally different from men in the trait of risk preference (Croson and Gneezy, 2009; Nelson, 2015). Altogether weak institutional environment may increase the transaction costs of innovation which may discourage women-led firms from innovating as female CEOs are known to be more risk-averse and conservative than men (Charness and Gneezy, 2012; Palvia, Vähämaa and Vähämaa, 2015).

The nature of informal institutions, such as corruption could be effectively used to analyze decision making as it both greasing or sanding a firm's ability to navigate innovation and the cost of transactions (Méon and Sekkat, 2005). On one hand, corruption could facilitate transactions and reduce inefficiency under conditions of severe formal voids (Webb et al. 2020). Paying a bribe could seem attractive to a firm if the bribe fee is less than the taxes and fees, or if it saves time by getting around the regulation. Corruption can also hurt business and increase uncertainty (Djankov et al., 2002) if bribes practices and expectations are not well-defined and unexpected (in other words, unpredictable) (Méon and Sekkat, 2005). This may increase the risk of bribing as it does not guarantee the outcome (arbitrary type of institutional environment). Corruption may also create an environment, in particular in a developing countries to enable firm activities like exports,

innovation and job creation by bypassing regulatory burdens and reducing uncertainty if a bribe is associated with less risk of doing business (pervasive-type of institutional environment).

Institutional environment is of pervasive type when the conditions are predictable and risk of non-complying with the agreements is low (Cuervo-Cazurra, 2008; Estrin et al., 2013). However, corruption and informalities are by nature hidden, so even when it is well-organized, the threat of change is still there. Corruption is endogenous by nature, meaning that bureaucrats can modify their bribe-seeking behavior (Wei and Kaufmann, 1999) increasing risk of doing business, also known as arbitrary type of corruption (Cuervo-Cazurra, 2008). Officials may arbitrarily decide to raise the bribe fees, or non-comply for a transaction, then corruption raises innovation costs and is likely to decrease innovation effort. Arbitrary corruption also means the manager may have to set aside resources for a "just in case" scenario each time there is going to be a transaction. It is less predictable, as the manager knows that there is no secure reduction in costs if bribe is paid. Market uncertainty lens suggests that this type of environment reduces predictability and may threaten managers to make decision to innovate, as the cost of innovation and the impediments to develop and commercialize it remain highly unknown.

While both scenarios are undesirable, more risk-averse manager will be more comfortable in environment which is associated with pervasive type of corruption, rather than arbitrary type. Two lines of argument are relevant to understanding how women-led firms will respond to two types of institutional contexts. Women are less likely to behave opportunistically (Dollar et al., 1999) and they will aim to avoid corruption, however in the environment where bribes are a norm (pervasive corruption), they will attempt to minimize risks by adjusting to the market behavior.

As women are more risk-averse (Croson and Gneezy, 2009) and more altruistic (Eckel and Grossman, 1998) than men in the arbitrary type of institutional environment which is characterized by uncertainty and high risk (Blackburn and Forgues-Puccio, 2009), a straightforward interpretation is women-led firms will either postpone innovation decision or abandon innovation. This implies that women-led firms will be more careful when it comes to innovation (Charness and Gneezy 2012).

Experimental methodologies demonstrated that women are not more intrinsically honest than men and rather they are more efficient to respond to the cultural and institutional context when institutional settings are clear (Frank et al., 2011). Country-level institutions also shape equity and fairness among women and men and can generally speaking, influence the broader environment in which female managers operate, as well as the way they are perceived by the stakeholders. It could be that the creativity gains from diversity on board and risk-aversion of women will allow firms to respond to weak institutions with more creative solutions (Estrin and Mickiewicz, 2011), while women take a greater advantage than men of institutional predictability (Esarey and Chirillo, 2013).

In addition, there is a robust evidence that males are more prepared to engage in aggressive behavior (Bushman & Huesmann, 2010), the interactive effect was, as Goldman and Hogg predicted, stronger among males than females, which makes men more adaptive to risks, with men taking a greater advantage than women of institutional hostility. We hypothesize:

H1: Women-led firms are more innovative in pervasive institutional environment, when uncertainty is low.

H2: Women-led firms are less innovative in arbitrary institutional environment, when uncertainty is high.

Another reason why women can take more (less) risks is associated with their access to resources (Brush, 2006; Brush et al. 2006, 2018; De Bruin et al., 2006; Gicheva and Link, 2013, 2015). In the institutionally strong and economically developed countries such as the United States, women seek angel financing at rates substantially lower than that of men but have an equal probability of receiving investment (Becker-Blease and Sohl, 2007). This may not be the case in developing economies. Estrin and Mickiewicz (2011) in their empirical work argued that women-led firms are disadvantaged in countries with weak institutions and corruption. Other studies also found that in many institutional contexts, women are restricted in their access to the economic resources needed for innovation, an in particular at the early stage of business growth (Brush, 2006; World Bank, 2019). That is the reason women respond differently to investment risks (Olsen and Cox, 2001), including limited venture investments in women-led firms (Balachandra et al. 2019; Jennings and Brush, 2013). This may hamper innovation in countries with high tax burden which imposes additional costs of innovation. As women-led firms in developing countries are more likely to experience gender-based discrimination as well as access to resources (Balachandra et al. 2019) working in a ‘‘man’s world’’ (Gupta, Turban, Wasti and Sikdar, 2009).

A large literature found mixed effects of fiscal freedom on business activity (Baliamoune-Lutz, 2015), with an increase in tax burden is likely to drain financial resources for innovation (Braunerhjelm, Eklund and Thulin, 2019), hamper risk taking behavior, R&D and market entry. Women-led firms may be particularly sensitive to high tax burden as it increases the cost of

doing business (Becker-Blease and Sohl, 2007; Gicheva and Link, 2013). An increase in resource availability and fiscal freedom creates the motivation to engage in entrepreneurial action and innovation activities (McMullen, Bagby and Palich, 2008), with women-led firms to be most affected. In addition to tax reduction it is reduction in government spending (Estrin et al. 2020), associated with diverting resources away from the private sector (McMullen et al. 2008) is important in motivating the risk-taking behavior in women-led firms. We hypothesize:

H3: Women-led firms are more innovative in countries with high fiscal freedom.

Access to resources for innovation is different across different stages of firm lifecycle (Belitski and Desai, 2019; Mickiewicz et al. 2017), with more mature firms accumulating substantial internal resources for innovation, while younger firms and start-ups will rely on external equity investment, debt finance and will be squeezed in resource availability (Olsen and Cox, 2001; Brush, 2006; Brush et al. 2006, 2018). We also learnt that equity investment is substantially limited for women-led firms at start up stage hindering innovation (Jennings and Brush, 2013; World Bank, 2019). We hypothesize:

H4: Women-led firms are more innovative at later stages of firm lifecycle.

3. Data and Method

Sample

We combine firm and country-level data for our sample. Our source for firm level data is the World Bank Enterprise Surveys (World Bank, 2015) as well as world bank development indicators (World Bank, 2018). We use one to two waves of the data for 75

countries during for two periods during 2008-2015. The World bank enterprise survey (2015) covers a wide range of topics, including leadership and ownership, performance, human capital, industry and business environment, institutional characteristics (e.g. corruption, financial and administrative obstacles of doing business). Self-reported data from firms is useful because "experience-based" information (Gonzalez et al., 2007) is likely more accurate than objective data, especially if managers in many developing economies underreport accounting data. The surveys include retrospective information which dates three years for a focal firm input.

We cleaned the data for outliers and used the maximum number of observations available for non-missing values for our model (1) and replaced all non-applicable with missing values, achieving two distinctive samples. Our full sample of 12,412 firms is used to test women-led likelihood of innovation in pervasive institutional environment, while the reduced sample consists of 5,052 firms is used to test this relationship in arbitrary institutional environment. The number of observations vary between two samples due to data availability for firm's characteristics related to arbitrary type of corruption which is less reported as they contain more sensitive corruption data. Interestingly, we do not find significant differences in means and standard deviations for dependent and explanatory variables in two samples (Table 1).

INSERT TABLE 1 ABOUT HERE

A composition of industries and firm size across both samples also demonstrates they are largely representative (see Table 2). Industries including food, metals and machinery, chemicals and pharmaceuticals, non-metallic and plastic materials make up to more than half of each sample. The Enterprise Surveys classifies small firms (<20 fulltime employees), medium firms

(20-99 fulltime employees) and large firms (>100 fulltime employees). Both models have a smaller proportion of small firms than medium firms.

INSERT TABLE 2 ABOUT HERE

The list of countries included in this study and additional information about our variables are in Table A1 (Appendix).

Dependent variable

Our firm-level dependent variable is product innovation, calculated as the binary variable equals one if a firm introduced new to market product or service, zero otherwise (Audretsch and Belitski, 2019, 2020).

Measures of innovation based on products (our dependent variable) is characterized by a lower bound of zero as no negative values are possible. Firms report zero in cases where no innovation project was undertaken, or this was not completed over the three-year period to which the questionnaire referred. Innovation plans may not have been completed within the three-year period because of one of the following reasons: the project was abandoned or seriously suspended; the project was seriously delayed with respect to initial planning; the project required more than three years to be completed. Firms reporting positive values of innovation have demonstrated commercialization of new products, while firms reporting missing values were not included.

Key explanatory variables

We use two measures for corruption, drawn from the World Bank Enterprise Survey

(World Bank, 2015). Pervasive corruption measures the likelihood that a firm will encounter demand for bribes when dealing with the government. Arbitrary corruption measures uncertainty regarding the demand for bribes (Cuervo-Cazurra, 2008), in terms of knowing in advance the expected bribe amount when applying for a water and telephone connection, import and operating licenses, or getting the service delivered after paying a bribe. Our corruption measures were created as aggregates using Cronbach alpha (Cronbach, 1951).

We use a binary variable "female management" if a top manager is a female (1 = yes; o = no), sourced from the question "Top manager is: Male/Female" from the Enterprise Surveys. We also know if the owner is a female.

The Fiscal Freedom Index refers to the absence of burdensome tax rates and government expenditures as a portion of GDP (Haan and Sturm, 2000; McMullen et al. 2008). Tax rates reflect the price of engaging in innovation activity. Increases in this price are expected to correspond to fewer individuals taking risks of new product development to market (Brush, 2006). Calculation of Fiscal Freedom Index (FFI) includes three components: The top marginal tax rate on individual income; The top marginal tax rate on corporate income, and The total tax burden as a percentage of GDP, with all three of them equally weighted (Heritage Foundation, 2020). Our final explanatory variable is firm age in years and is included with a quadratic term in the equation to capture differences in the level of innovation and resource availability across different stages of firm lifecycle (Belitski and Desai, 2019). We created four interactions by multiplying female management with both types of corruption, FFI and firm age.

Control variables

We control for country and firm level characteristics. The inclusion of country

characteristic enables us to further control the impact of institutional environment (North, 1990) on innovation in women-led firms. We include gender specific institutions reflecting the state of female labor market access, level of maternity protection and equal rights (Cuervo-Cazurra, 2008). More specifically, we include the share of seats held by women in national parliaments as a proxy for women's political empowerment from the World Bank. We used binary variable discrimination to identify whether or not a country ratified the C111 - Discrimination (Employment and Occupation) Convention, 1958 (No. 111), which concerns discrimination in respect of employment and occupation (entry into force 15 Jun 1960) (ILO, 2018). We used binary variable maternity to identify whether or not a country ratified the C003 - Maternity Protection Convention, 1919 (No. 3), which concerns the employment of women before and after childbirth (Entry into force:13 Jun 1921) (ILO, 2018).

We include female labor force participation rate, female (% of female population ages 15+) from the World Bank (2018). To measure the level of economic development we included the logarithm of gross domestic product (GDP) per capita in constant 2010 prices as well as a binary variable of low-income country according to the World Bank classification (2018). We interacted for low-income country binary variable and GDP per capita to understand how the extent of economic development may change innovation for firms in low-income countries.

We also control for firm level characteristics that may affect the likelihood of innovation. We use the number of full-time employees as a proxy for firm size, taken in logarithms. We also included if a firm licenses foreign technology from a foreign firm (yes=1; 0=no) to measure the extent of advanced technology use and knowledge

collaboration with external partners (West and Bogers, 2017; Belitski and Desai, 2016). In addition, we measure the use of digital technologies by including a binary variable whether or not firms employ emails for communication with partners and clients (1=yes, 0=no), which may be an indicator of internet connectedness and e-commerce for developing countries. We include a binary variable Web if a firm has a corporate website to connect with customers and suppliers, operating within a vertical supply and demand chain (Li et al. 2016). Manager perceptions about fairness in the court system may change the decision to innovate and enforce contracts (Audretsch et al. 2019) which affects and subsequent decision-making. Court system perception illustrates the extent to which a manager considers the legislative system fair and uncorrupted (-4) or unfair (-1) (Chowdhury et al. 2019).

In order to control for female labor force participation in a firm (Bednar and Gicheva, 2014) we include female high-skill engagement, which is measured by the percentage of the highly skilled female labor force, reflecting collective high-level female human capital. We measured female production engagement as the proportion of females engaged in non-skilled production activity (Weber and Zulehner, 2010; Belitski and Desai, 2019). Finally, we use industry and year fixed effects to control for industry-specific and year unobserved heterogeneity.

Estimation strategy

Our estimation strategy is congruent with the firm and country-level data availability and design (Siepel and Dejardin, 2020). We estimate two logistic (logit) models for product innovation using pervasive and arbitrary institutional environments and FFI in each model (Wooldridge, 2009). Our dependent variable is binary y_i (firm's propensity to introduce new to

market products/ services):

$$Prob(y_i = 1) = \beta_0 + \beta_{1i}x_{1i} + \lambda_1 S_{ir} + \beta_{2i}x_{2i} + \delta_i + \omega_r + \varphi_t + u_i \qquad (1)$$

Equation (1) is the logistic cumulative distribution function. Vector S_{ir} is explanatory variables (corruption type, Fiscal Freedom Index, female top manager) of while x_{1i} is a vector of the firm's characteristics and x_{2i} is a vector of the country characteristics and u_i is an error term. (Wooldridge, 2009). Vectors $\delta_i, \omega_r, \varphi_t$ are industry, region and time fixed effects. A bootstrapping of errors was also applied and OLS which led to similar results in terms of the sign and significance of all confidents, but of a different size.

We started by exploring the multicollinearity of the variables by examining the variance inflation factors for all variables, finding each less than 10. In addition, we analysed the correlation coefficients ensuring that no coefficients were greater than 0.70. We analysed all the variables' histograms and found the errors were identically and independently distributed with constant variance.

4. Results

Results related to the main hypothesis are reported in Table 3.

INSERT TABLE 3 ABOUT HERE

Our results are robust across all five specifications in the full (specification 1-6) and reduced samples (specification 7-12), including and excluding country-level characteristics, and gender-specific national institutions. Our findings do not support H1 and H2 which predict that women-led firm's innovation propensity depends on the pervasive or arbitrary intuitional environment, where a focal firm is embedded. We find that pervasive institutional environment is associated with lower firm' propensity to

innovate, while we do not find the relationship for the arbitrary institutional environment. Interestingly that both interactions of female management with pervasive (specifications 1-6) and arbitrary (specifications 7-12) environments are not statistically significant. Figure 1 A and B illustrate the predictive margins of innovation propensity in women-led firms vs. men-led firms across two types of institutional contexts and using the full and reduced samples.

From the extent literature on the nature of risk-taking women, by virtue are fundamentally, and/or categorically different from men in the trait of risk preference (Palvia et al., 2015Nelson, 2015). Our results do not directly support Nelson (2015) and Croson and Gneezy (2009) as we have found that innovation in wopmen-led firms does not change with the type of corrupt environment.

Other factors can explain why and when women-led firms will exhibit more innovation. Interestingly, the prior literature emphasizes the fact that women-led businesses diverge from those of men as they need 'distinctively different financial investment advice' (Nelson, 2015: 566). This claim was also discussed in Brush (2006), Estrin and Mickiewicz (2011) and more recently by Balachandra et al. (2019). Our H3 is supported, which means that women-led firms will increase the likelihood of innovation from 1.03 to 1.04 times with every one-unit increase in country's fiscal freedom index (specification 3-6, Table 3) and from 1.03 to 1.06 times (specification 9-12, Table 3). As debated earlier, women are more likely to be constrained with access to resources.

We found that women-led firms in countries with a lower FFI will be less innovative as the tax burden is high and less resources are left to invest in R&D and innovation (McMullen et al. 2008; Chowdhury et al. 2019). Figure 1C and 1B illustrate using the full and reduced samples that high levels of fiscal freedom (after 80) results in an exponential increase in the probability to

innovate. While both women and men-led firms increase innovation propensity, the rise is higher for women-led firms (see Figures 1C, D). The confidence intervals of the interaction coefficients remain robust between specifications 4, 5 and 9, 10 (Table 3). Women will be more likely to innovate at a later stages of firm lifecycle (30 years since establishment and more), supporting H4. Figures 1E and 1F illustrate different innovation levels for women-led firms at the early stages of firm lifecycle and during the firm maturity. While innovation in men-led firms decreases over time, accumulation of internal resources for innovation at the later stages of firm lifecycle enhance female management decision-making on innovation.

Results for our control variables are similar when using pervasive or arbitrary corruption and consistent across two models. Our findings indicate a neutral relationship between firm age and innovation, while firm size decreases as one would expect decreases innovation propensity. The use of digital technologies such as email and websites boost innovation propensity (Li et al. 2016), and bureaucratic burden proxied by the frequency of inspections as well as institutional trust is negatively associated with innovation propensity. Firms that use foreign technology are less likely to innovate new to market products as they use ready-made solutions by providers of such technology. We found that engagement if highly skilled female workers is positively associated with innovation propensity as well as female employees with low level of skills will positively affect innovation propensity. Overall, an increase of female workers both with high and low level of human capital is positively associated with innovation propensity. This finding supports Weber and Zulehner (2010) who studied the relationship between female hires in startup firms in Austria with firm performance. They found that firms that start off with more female

employees have higher survival rates. A decrease in trust to court institutions is negatively associated with innovation, as firm managers will be less likely to take risks of innovation and uncertainty. Economic development is positively associated with innovation propensity, increasing it between 1.6 (specification 10, Table 3) and 2.4 times for every one percent increase in GDP per capita (Specification 5, Table 3). We also found that an increase in economic development for low income countries may not be enough to start innovating. Our findings for gender institutions call for further research on the role of gender institutions. Countries that adopted gender equality institutions, such as maternity leave and non-discrimination in labor market on average have women-led firms innovating less than men-led firms. This is puzzling as one would expect more female top managers taking risks if they are more protected. This finding confirms Estrin and Mickiewicz (2011) who found that the provision of maternity leave does not affect high aspiration female entrepreneurship, but it is the provision of childcare which increase female entrepreneurship. One of the possible explanations to this phenomenon is that maternity protection and labor market non-discrimination in addition to other improvements in gender-related institutional quality create a "safety net", increasing the opportunity costs of doing business and innovating in women led firms. More research is required to unpack the effects, which are very likely non-linear (Audretsch et al. 2019).

5. Discussion and Conclusion

Our findings provide new insight into the role of nature proxied by pervasive and arbitrary institutional environment as well as FFI in shaping innovation in women-led firms (Elam and Terjesen, 2010; Ding, Murray and Stuart, 2006; Dohse et al. 2019; Link, 2019b). Our findings open a natural environment lens through which to study innovation and female management.

First, we present a model and explain why women-led firms are likely to exhibit more innovative activity. Our results confirm that neither pervasive nor arbitrary institutional environment which is associated with different level of risk-taking explains innovation in women-led firms. Our finding on arbitrary and pervasive corruption have demonstrated that corruption is not gender biased. This is surprising as both women and men-led firms respond similarly to market risks and uncertainty related to corruption. Our finding contrasts Estrin and Mickiewicz (2011) who have demonstrated that women-led firms will be less likely than men-led firms to undertake entrepreneurial activity in countries where institutions are weaker. Unlike entrepreneurship activity, innovation is associated with different stages of firm life cycle (Mickiewicz et al. 2017; Braunerhjelm et al. 2019) and hence firms may be more prepared to adjust to corruption at later stages of firm lifecycle. If this is the case, both females and males managers should be able to tolerance corruption . Second, pervasive risk-free environment is still associated with corrupt practices which women may not want to engage with (Eckel and Grossman, 1998). Third, innovation activity is likely to be long term, and unlike firm's sales, the response to pervasive corruption embedded in local institutions can be negative, which means lower innovation effort by firms. Finally, this finding can be due to measurement error of arbitrary and pervasive corruption which is difficult to capture (Cuervo-Cazurra, 2008; Galtung et al., 2013).

What is more likely to matter for innovation decision by females managers is access to finance and resource availability (Gicheva and Link, 2013, 2015). We interpret the positive results for innovation in women-led firms in countries with high level of fiscal freedom as consistent with research on women be more sensitive to financial support and

access to resources (Brush et al. 2006; Balachandra et al. 2019). It follows from the research that women will be more responsive to trade-offs between domestic work and outside involvement, and so will respond more strongly to greater incentives to gain additional income to invest in innovation. We also found that internal resources could be used for innovation at mature stage of firm lifecycle. Females managers may be willing to take more innovation risks, if they have resources to do so.

Our findings contribute to economics of innovation literature by demonstrating that the key element in making women-led firm innovate is not the reduction of the transaction costs of innovation (including uncertainty), rather it is an increased access to resources, including firm internal resources and firm income after tax. If gender inequality in access to capital and in particular in developing countries persists (Gicheva and Link, 2013), the former may affect innovation behavior in particular in women-led firms (De Bruin et al. 2006; Jennings and Brush, 2013; Brush et al., 2018). This will result in divergence of innovation activity in women-led firms at the startup and mature stages of firm lifecycle. At later stages of firm lifecycle ,female managers may be less effected by uncertainty and may accumulate more resources to innovate (Greene et al. 2001; Gicheva and Link, 2015).

Our study also contributes to gender and innovation literature by demonstrating that women-led firms are less likely than men-led firms to undertake innovation in the countries where fiscal freedom is weaker (Estrin and Mickiewicz, 2011). Moreover, access to financial resources mean that, in relative terms, female managers have to rely to a greater extent on informal social networks for resource acquisition at startup stages and those networks tend to be male-dominated in developing countries (Aidis et al. 2008; World Bank, 2019).

We also advanced management literature on the role that nature can play in driving innovation (Bednar et al. 2019) and the interplay between institutions, corruption and female management.

Our study has several limitations. First, we were unable to dive into psychological or neurological factors that could determine intrinsic qualities of female and male managers when taking decisions related to risk and uncertainty. While our H1-H2 are not supported, the reason for this could be measurement of risk environment associated with two types of informal practices. Using other proxies for pervasive and arbitrary institutional environment can be useful for further research. Without controlling for individual characteristics of female managers we cannot confirm that corruption and innovation are is gender free or that women are not prone to engage in corrupt behavior at all. For example, age of female manager could be important in risk taking behavior. If we look at women entrepreneurs at different age groups one can find different risk-taking patterns.

Second, our data is cross-sectional, which does not allow to enforce causal interpretation of our findings. Future research will use longitudinal cross-country data to measure changes in innovation behavior in women-led firms as institutional environment changes. Finally, we found that access to finance is crucial for innovation in women-led firms. Pandemic and other world crises in developing countries may shrink credit markets and result in an increase in government spending, higher taxes and less take-home income. This situation endangers the least privileged minorities and women, who struggle to accumulate resources in scarcity and access finance. Policymakers should bear in mind that innovation in women-led firms is unlikely to be enhanced with high tax burden and weak fiscal freedom quality (McMullen et al. 2008). Further research may explore the

consequences in government size and institutional quality on innovation in women vs. men-led firms.

References

Aidis, Ruta, Saul Estrin, and Tomasz Mickiewicz. 2008. "Institutions and entrepreneurship development in Russia: A comparative perspective." *Journal of business Venturing* 23(6): 656-672.

Audretsch, David B., Maksim Belitski, and Sameeksha Desai. 2019. "National business regulations and city entrepreneurship in Europe: A multilevel nested analysis." *Entrepreneurship theory and practice* 43: 1148-1165.

Audretsch, David B., and Maksim Belitski. 2019. "The limits to collaboration across four of the most innovative UK industries." *British Journal of Management*.

Audretsch, David B., and Maksim Belitski. 2020. "The role of R&D and knowledge spillovers in innovation and productivity." *European Economic Review* 123: 103391.

Baker, Ted, Eric Gedajlovic, and Michael Lubatkin. 2005. "A framework for comparing entrepreneurship processes across nations." *Journal of International Business Studies* 36(5): 492-504.

Baliamoune-Lutz, Mina. 2015. "Taxes and entrepreneurship in OECD countries." *Contemporary Economic Policy* 33(2): 369-380.

Balachandra, Lakshmi, Tony Briggs, Kim Eddleston, and Candida Brush. 2019. "Don't pitch like a girl!: how gender stereotypes influence investor decisions." *Entrepreneurship Theory and Practice* 43(1): 116-137.

Bednar, Steven, and Dora Gicheva. 2014. "Are female supervisors more female-friendly?." *American Economic Review* 104(5): 370-75.

Bednar, Steven, Dora Gicheva, and Albert N. Link. 2019. "Innovative activity and gender dynamics." *Small Business Economics*: 1-9.

Belitski, Maksim, and Sameeksha Desai. 2016. "What drives ICT clustering in European cities?." *The Journal of Technology Transfer* 41(3): 430-450.

Belitski, Maksim, Farzana Chowdhury, and Sameeksha Desai. 2016. "Taxes, corruption, and entry." *Small Business Economics* 47(1): 201-216.

Belitski, Maksim, and Sameeksha Desai. 2019. "Female ownership, firm age and firm growth: a study of South Asian firms." *Asia Pacific Journal of Management* : 1-31.

Becker-Blease, John R., and Jeffrey E. Sohl. 2007. "Do women-owned businesses have equal access to angel capital?." *Journal of Business Venturing* 22(4): 503-521.

Blackburn, Keith, and Gonzalo F. Forgues-Puccio. 2009. "Why is corruption less harmful in some countries than in others?." *Journal of Economic Behavior & Organization* 72(3): 797-810.

Braunerhjelm, Pontus, Johan E. Eklund, and Per Thulin. 2019. "Taxes, the tax administrative burden and the entrepreneurial life cycle." *Small Business Economics*: 1-14.

Brush, Candida. 2006. Women entrepreneurs: A research overview. In M. Casson, B. Yeung, A. Basu, & N. Wadeson (Eds.), Oxford handbook of entrepreneurship (pp. 611–628). Oxford UK: Oxford University Press.

Brush, Candida G., Nancy M. Carter, Elizabeth J. Gatewood, Patricia G. Greene, and Myra M.

Hart. 2006. "Women's entrepreneurship in the United States." *Growth-Oriented Women Entrepreneurs and their Businesses: A Global Research Perspective, Cheltenham, UK and Northampton, MA, USA: Edward Elgar*: 184-202.

Brush, Candida G., Anne De Bruin, and Friederike Welter. 2009. "A gender-aware framework for women's entrepreneurship." *International Journal of Gender and entrepreneurship*.

Brush, Candida, Patricia Greene, Lakshmi Balachandra, and Amy Davis. 2018. "The gender gap in venture capital-progress, problems, and perspectives." *Venture Capital* 20(2): 115-136.

Charness, Gary, and Uri Gneezy. 2012. "Strong evidence for gender differences in risk taking." *Journal of Economic Behavior & Organization* 83(1): 50-58.

Chowdhury, Farzana, David B. Audretsch, and Maksim Belitski. 2019. "Institutions and entrepreneurship quality." *Entrepreneurship Theory and Practice* 43(1): 51-81.

Cronbach, Lee J. 1951. "Coefficient alpha and the internal structure of tests". *Psychometrika*. 16(3): 297-334.

Croson, Rachel, and Uri Gneezy. 2009. "Gender differences in preferences." *Journal of Economic literature* 47(2): 448-474.

Cuervo-Cazurra, Alvaro. 2006. "Who cares about corruption?." *Journal of international business studies* 37(6): 807-822.

Cuervo-Cazurra, Alvaro. 2008. "Better the devil you don't know: Types of corruption and FDI in transition economies." *Journal of International Management* 14(1): 12-27.

De Bruin, Anne, Candida G. Brush, and Friederike Welter. 2006. "Introduction to the special issue: Towards building cumulative knowledge on women's entrepreneurship." *Entrepreneurship Theory and practice* 30(5): 585-593.

Ding, Waverly W., Fiona Murray, and Toby E. Stuart. 2006. "Gender differences in patenting in the academic life sciences." *Science* 313(5787): 665-667.

Djankov, Simeon, Rafael La Porta, Florencio Lopez-de-Silanes, and Andrei Shleifer. 2002. "The regulation of entry." *The quarterly Journal of economics* 117(1): 1-37.

Dohse, Dirk, Rajeev K. Goel, and Michael A. Nelson. (2019) "Female owners versus female managers: Who is better at introducing innovations?." *The Journal of Technology Transfer* 44(2): 520-539.

Dollar, David, Raymond Fisman, and Roberta Gatti. 2001. "Are women really the "fairer" sex? Corruption and women in government." *Journal of Economic Behavior & Organization* 46(4): 423-429.

Eckel, Catherine C., and Philip J. Grossman. 1998. "Are women less selfish than men?: Evidence from dictator experiments." *The economic journal* 108(448): 726-735.

Elam, Amanda, and Siri Terjesen. 2010. "Gendered institutions and cross-national patterns of business creation for men and women." *The European Journal of Development Research* 22(3): 331-348.

Esarey, Justin, and Gina Chirillo. 2013. ""Fairer sex" or purity myth? Corruption, gender, and institutional context." *Politics & Gender* 9(4): 361-389.

Estrin, Saul, Julia Korosteleva, and Tomasz Mickiewicz. 2013. "Which institutions encourage entrepreneurial growth aspirations?." *Journal of business venturing* 28(4): 564-580.

Estrin, Saul, and Tomasz Mickiewicz. 2011. "Institutions and female entrepreneurship." *Small business economics* 37(4): 397.

Frank, Björn, Johann Graf Lambsdorff, and Frédéric Boehm. 2011. "Gender and corruption: Lessons from laboratory corruption experiments." *The European Journal of Development Research* 23(1): 59-71.

Fredriksson, Anders. 2014. "Bureaucracy intermediaries, corruption and red tape." *Journal of Development Economics* 108: 256-273.

Gicheva, Dora, and Albert N. Link. 2013. "Leveraging entrepreneurship through private investments: does gender matter?." *Small Business Economics* 40(2): 199-210.

Gicheva, Dora, and Albert N. Link. 2015. "The gender gap in federal and private support for entrepreneurship." *Small Business Economics* 45(4): 729-733.

Gonzalez, Alvaro, J. Ernesto López-Córdova, and Elio E. Valladares. 2007. *The incidence of graft on developing-country firms*. The World Bank, 2007.

Greene, Patricia G., Candida G. Brush, Myra M. Hart, and Patrick Saparito. 2001. "Patterns of venture capital funding: is gender a factor?." *Venture Capital: An international journal of entrepreneurial finance* 3(1): 63-83.

Gupta, Vishal K., Daniel B. Turban, S. Arzu Wasti, and Arijit Sikdar. 2009. "The role of gender stereotypes in perceptions of entrepreneurs and intentions to become an entrepreneur." *Entrepreneurship theory and practice* 33(2): 397-417.

De Haan, Jakob, and Jan-Egbert Sturm. 2000. "On the relationship between economic freedom and economic growth." *European Journal of Political Economy* 16(2): 215-241.

Heritage Foundation. 2020. Index of Economic Freedom. Fiscal freedom. Available at: https://www.heritage.org/index/fiscal-freedom. Accessed February 13th, 2020.

ILO. 2018. International Labour Organization. Ratifications of C111 - Discrimination (Employment and Occupation) Convention, 1958 (No. 111) and Ratifications of C003 - Maternity Protection Convention, 1919 (No. 3). Available at:
https://www.ilo.org/dyn/normlex/en/f?p=1000:11300:0::NO:11300:P11300_INSTRUMENT_ID (assessed 15 April 2019)

Jennings, Jennifer E., and Candida G. Brush. 2013. "Research on women entrepreneurs: challenges to (and from) the broader entrepreneurship literature?." *The Academy of Management Annals* 7(1): 663-715.

Li, Weizi, Kecheng Liu, Maksim Belitski, Abby Ghobadian, and Nicholas O'Regan. 2016 "e-Leadership through strategic alignment: An empirical study of small-and medium-sized enterprises in the digital age." *Journal of Information Technology* 31(2): 185-206.

Link, Albert N., and Derek R. Strong. 2016. "Gender and entrepreneurship: An annotated bibliography." *Foundations and Trends® in Entrepreneurship* 12(4–5): 287-441.

Link, Albert N. "Technology transfer at the US National Institute of Standards and Technology. 2019a. " *Science and Public Policy* 46(6): 906-912.

Link, Albert N., and John T. Scott. 2019. "Creativity-enhancing technological change in the production of scientific knowledge." *Economics of Innovation and New Technology*: 1-12.

Link, Albert N. 2019b "Innovative behavior of minorities, women, and immigrants." *Economics of Innovation and New Technology*, 28(7): 758.

McMullen, Jeffery S., D. Ray Bagby, and Leslie E. Palich. 2008. "Economic freedom and the motivation to engage in entrepreneurial action." *Entrepreneurship Theory and Practice* 32(5): 875-895.

Méon, Pierre-Guillaume, and Khalid Sekkat. 2005. "Does corruption grease or sand the wheels of growth?." *Public choice* 122(1-2): 69-97.

Mickiewicz, Tomasz, Frederick Wedzerai Nyakudya, Nicholas Theodorakopoulos, and Mark Hart. 2017. "Resource endowment and opportunity cost effects along the stages of entrepreneurship." *Small Business Economics* 48(4): 953-976.

Nählinder, Johanna. 2010. "Where are all the female innovators?: Nurses as innovators in a

public sector innovation project." *Journal of technology management & innovation* 5(1): 13-29.

Nelson, Julie A. 2015. "Are women really more risk-averse than men? A re-analysis of the literature using expanded methods." *Journal of Economic Surveys* 29(3): 566-585.

North, Douglass C. 1990. "A transaction cost theory of politics." *Journal of theoretical politics* 2(4): 355-367.

Olsen, Robert A., and Constance M. Cox. 2001. "The influence of gender on the perception and response to investment risk: The case of professional investors." *The journal of psychology and financial markets* 2(1): 29-36.

Palvia, Ajay, Emilia Vähämaa, and Sami Vähämaa. 2015. "Are female CEOs and chairwomen more conservative and risk averse? Evidence from the banking industry during the financial crisis." *Journal of Business Ethics* 131(3): 577-594.

Shleifer, Andrei, and Robert W. Vishny. 1993. "Corruption." *The quarterly journal of economics* 108(3): 599-617.

Siepel, John, and Marcus. Dejardin. 2020. "How do we measure firm performance? A review of issues facing entrepreneurship researchers". To be published in G. Saridakis and M. Cowling, eds, Handbook of Quantitative Research Methods in Entrepreneurship, Edward Elgar Publishing

Swamy, Anand, Stephen Knack, Young Lee, and Omar Azfar. 2001. "Gender and corruption." *Journal of development economics* 64(1): 25-55.

Szerb, Laszlo, Gábor Rappai, Zsolt Makra, and Siri Terjesen. 2007. "Informal investment in transition economies: Individual characteristics and clusters." *Small Business Economics* 28(2-3): 257-271.

Thursby, Jerry G., and Marie C. Thursby. 2005. "Gender patterns of research and licensing activity of science and engineering faculty." *The Journal of Technology Transfer* 30(4): 343-353

Verheul, Ingrid, André Van Stel, and Roy Thurik. 2006. "Explaining female and male entrepreneurship at the country level." *Entrepreneurship and regional development* 18(2): 151-183.

Weber, Andrea, and Christine Zulehner. 2010. "Female hires and the success of start-up firms." *American Economic Review* 100(2): 358-61.

Webb, Justin W., Theodore A. Khoury, and Michael A. Hitt. 2020. "The influence of formal and informal institutional voids on entrepreneurship." *Entrepreneurship Theory and Practice* 44(3): 504-526.

Wei, Shang-Jin, and Daniel Kaufmann. 1999. *Does grease money speed up the wheels of commerce?*. The World Bank.

West, Joel, and Marcel Bogers. 2017. "Open innovation: current status and research opportunities." *Innovation* 19 (1): 43-50.

Williamson, Oliver E. 2000. "The new institutional economics: taking stock, looking ahead." *Journal of economic literature* 38(3): 595-613.

Wooldridge, Jeffrey M. 2009. "Introductory economics: A modern approach." *Mason, Cengage-Learning*.

World Bank. 2015. World Bank Enterprise Survey Available at: http://www.enterprisesurveys.org/ (assessed 15 April 2019)

World Bank. 2018. World Bank Indicators. Available at https://data.worldbank.org/indicator Accessed February 05 2019.

World Bank, 2019. Female Entrepreneurship Resource Point - Introduction and Module 1: Why Gender Matters. http://www.worldbank.org/en/topic/gender/publication/female-entrepreneurship-resource-point-introduction-and-module-1-why-gender-matters (accessed 14 March 2019).

Table 1. Descriptive statistics

Variables	Description	Full sample (12,412 obs.)				Reduced sample (4,714 obs.)			
		Mean	St.dev	Min	Max	Mean	St.dev	Min	Max
Innovation	Binary variable=1 if firm introduced new to market product or service during the last 3 years, zero otherwise	0.13	0.33	0.00	1.00	0.09	0.29	0.00	1.00
Foreign Technology	Technology licensed from a foreign-owned company	0.83	0.38	0.00	1.00	0.79	0.40	0.00	1.00
Firm age	Age of firm, years	19.72	13.85	0.00	74.00	20.54	14.98	0.00	72.00
Female management	Top manager female 1=yes, 0=no	0.11	0.31	0.00	1.00	0.11	0.31	0.00	1.00
Female high-skill	Proportion of female in non-production activities (high-skilled)	8.33	10.99	0.00	100.00	9.25	11.60	0.00	100.00
Female low-skill	Proportion of female in production activities (low -skilled)	17.59	24.07	0.00	100.00	17.33	23.25	0.00	100.00
Firm size	Number of Full Time Employees (FTEs), in logs	3.85	1.38	0.69	9.74	3.99	1.40	0.69	9.74
Digital readiness- Email	Email is used to communicate value chain	0.79	0.40	0.00	1.00	0.84	0.37	0.00	1.00
Digital readiness- Web	Wed-site is used to communicate value chain	0.55	0.50	0.00	1.00	0.60	0.49	0.00	1.00
Senior management time	% of C-level management time spent in dealing with government regulations?	11.50	18.32	0.00	100.00	13.66	19.03	0.00	100.00
Frequency of inspections	Frequency of inspections a year /requirement for meeting by tax officials	3.42	4.53	1.00	30.00	4.26	5.57	1.00	30.00
Court system perception	Court system is unfair and corrupted -1 corrupted - 4 not corrupted	-2.39	1.02	-4.00	-1.00	-2.23	1.00	-4.00	-1.00
Pervasive corruption	Cronbach alpha (>0.70) of pervasive corruption in the host country, from -3 (low) to 3 (high), composite of share sales paid in informal payments % (1); need to offer a gift when expected by public officials, (2) share of contract value in informal gifts to government officials to secure contract, (3)	-0.05	0.79	-0.41	9.06				
Arbitrary corruption	Cronbach alpha (>0.70) of arbitrary corruption in the host country, from -3 (low) to 3 (high) unofficial payment when applied for a water connection (1), applied for a telephone connection and an informal gift requested (2), applied for an import license and an informal gift requested (3), applied for an operating license and an informal gift requested (4).					-0.003	0.94	-3.70	0.45
FFI	Fiscal freedom Index ij= $100 - \alpha (\text{Factor ij})^2$ where Fiscal Freedom ij represents the fiscal freedom in country i for factor j; Factor ij represents the value (based on a scale of 0 to 100) in country i for factor j; and α is a coefficient set equal to 0.03 (Heritage Foundation, 2020).	79.82	5.76	60.20	96.60	79.53	5.30	60.20	96.60

Seats	Proportion of seats held by women in national parliaments (%), World Bank (2018)	15.86	9.34	0.00	43.30	16.84	8.93	0.00	43.30
Discrimination	Binary variable=1 if country ratified the C111 - Discrimination (Employment and Occupation) Convention, 1958 (No. 111), zero otherwise (ILO, 2018)	0.93	0.26	0.00	1.00	0.89	0.31	0.00	1.00
Maternity	Binary variable=1 if country ratified C003 - Maternity Protection Convention, 1919 (No. 3), zero otherwise (ILO, 2018)	0.12	0.32	0.00	1.00	0.14	0.34	0.00	1.00
FLPR	Female labor participation rate, World Bank (2018)	41.78	16.34	6.88	86.70	44.36051	16.11	6.84	86.69
Low income	Countries classified by the World Bank (2018) as low income and low-middle income (<3,895 Gross National Income per capita).	0.64	0.48	0.00	1.00	0.57	0.49	0.00	1.00
Economic development	GDP per capita in constant 2010 prices (logarithm) (World, Bank (2016)	3.47	0.42	2.50	4.56	3.51	0.42	2.50	4.56

Source: World Bank (2015, 2018), ILO (2018)

Table 2. Averages of main variables split by industry and firm across two models

Industry	Full sample = 12,412 obs.				Reduced sample = 5,052 obs.			
	obs.	% in total	% female manager	pervasive corruption	obs.	% in total	% female manager	arbitrary corruption
Textiles	873	7.03	0.10	0.01	256	5.07	0.14	0.10
Leather	62	0.50	0.03	-0.09	54	1.07	0.00	-0.50
Garments	1105	8.90	0.23	-0.03	373	7.38	0.23	-0.03
Food	2345	18.89	0.12	-0.06	935	18.51	0.13	0.09
Metals and machinery	2433	19.60	0.06	-0.06	943	18.67	0.06	-0.05
Electronics	372	3.00	0.10	0.06	138	2.73	0.11	0.00
Chemicals and pharmaceuticals	1022	8.23	0.12	-0.08	450	8.91	0.14	0.04
Wood and furniture	448	3.61	0.09	0.04	196	3.88	0.18	-0.05
Non-metallic and plastic materials	1668	13.44	0.07	0.00	717	14.19	0.06	0.02
Auto and auto components	236	1.90	0.03	0.06	88	1.74	0.02	-0.47
Other manufacturing	975	7.86	0.10	-0.08	397	7.86	0.09	-0.02
Retail and wholesale trade	179	1.44	0.09	0.03	155	3.07	0.11	-0.12
Hotels and restaurants	174	1.40	0.12	-0.04	110	2.18	0.18	0.23
Other services	325	2.62	0.04	0.15	126	2.49	0.05	-0.36
Other: Construction, Transportation	195	1.57	0.04	0.29	114	2.26	0.06	-0.66

Firm size split								
Small (<20)	3760	30.29	0.11	-0.01	1,534	30.36	0.13	-0.01
Medium Small (20-99)	4997	40.26	0.09	0.00	1,906	37.73	0.10	-0.09
Medium large and large (100 and over)	3655	29.45	0.10	-0.08	1,612	31.91	0.10	0.08

Source: World Bank (2015, 2018), ILO (2018)

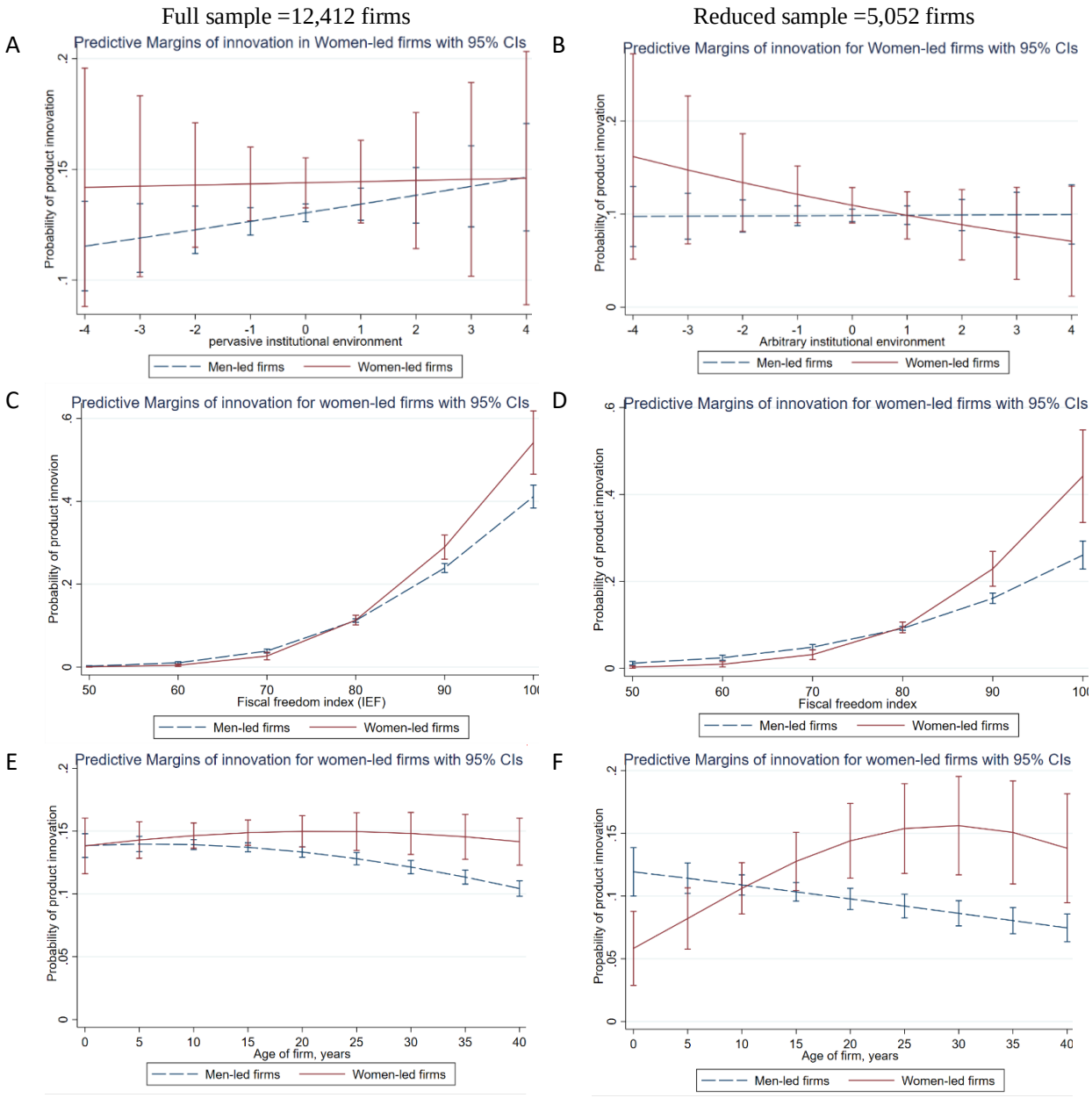
Table 3: Logistic estimation results for innovation in women-led firms: Dependent variable =product (service) innovation [0,1]

Sample	Full sample = 12,412 firms						Reduced sample = 5,052 firms					
Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Foreign Technology	0.74*** (0.05)	0.70*** (0.05)	0.71*** (0.05)	0.85** (0.06)	0.81** (0.07)	0.81** (0.06)	0.64*** (0.07)	0.63*** (0.07)	0.63*** (0.07)	0.75** (0.09)	0.77* (0.10)	0.78* (0.10)
Firm Age	1.04* (0.01)	1.03* (0.01)	1.03* (0.01)	1.01* (0.01)	1.05* (0.01)	1.01* (0.01)	1.01 (0.01)	1.02 (0.01)	1.001 (0.01)	1.05 (0.01)	1.02 (0.01)	0.98 (0.01)
Firm Age (squared)	1.01*** (0.00)	1.02** (0.00)	1.02** (0.00)	0.99*** (0.00)	1.00*** (0.00)	0.99*** (0.00)	0.99 (0.00)	0.99 (0.00)	0.99 (0.00)	0.99 (0.00)	0.99 (0.00)	0.99 (0.01)
Female management	1.01 (0.09)	1.02 (0.09)	0.07** (0.09)	0.03** (0.04)	0.05* (0.08)	0.03* (0.05)	1.11 (0.17)	1.06 (0.17)	0.06 (0.16)	0.01 (0.04)	0.03 (0.11)	0.001* (0.00)
Female high-skill	1.01*** (0.00)	1.01*** (0.00)	1.01*** (0.00)	1.01*** (0.00)	0.998 (0.00)	0.99 (0.00)	0.99 (0.00)	0.99 (0.00)	0.99 (0.00)	0.99* (0.01)	0.98** (0.01)	0.98** (0.01)
Female low-skill	1.01*** (0.00)	1.02*** (0.00)	1.02*** (0.00)	1.02*** (0.00)	1.01*** (0.00)	1.01** (0.00)	1.01*** (0.00)	1.04*** (0.00)	1.01*** (0.00)	1.01*** (0.00)	1.01*** (0.00)	1.02*** (0.00)
Firm size	0.71*** (0.02)	0.73*** (0.02)	0.73*** (0.02)	0.72*** (0.02)	0.75*** (0.02)	0.75*** (0.02)	0.81*** (0.03)	0.80*** (0.04)	0.87*** (0.04)	0.79*** (0.04)	0.81*** (0.04)	0.80*** (0.04)
Digital readiness-Email	2.06*** (0.18)	2.26*** (0.20)	2.24*** (0.20)	2.24*** (0.22)	1.49*** (0.16)	1.48*** (0.16)	1.71*** (0.32)	1.84*** (0.35)	1.84*** (0.35)	1.76*** (0.34)	1.19 (0.26)	1.20 (0.26)
Digital readiness-Web	1.94*** (0.13)	1.96*** (0.13)	1.96*** (0.13)	1.86*** (0.14)	1.43*** (0.12)	1.43*** (0.12)	1.93*** (0.24)	1.93*** (0.25)	1.93*** (0.25)	1.76*** (0.24)	1.35** (0.20)	1.39** (0.20)
Frequency of inspections	0.92*** (0.01)	0.93*** (0.01)	0.92*** (0.01)	0.93*** (0.01)	0.93*** (0.01)	0.93*** (0.01)	0.88*** (0.02)	0.89*** (0.02)	0.89*** (0.02)	0.90*** (0.02)	0.91*** (0.02)	0.90** (0.02)
Court system perception	1.09*** (0.03)	1.08*** (0.03)	1.08*** (0.03)	0.91*** (0.03)	0.86*** (0.03)	0.86*** (0.03)	0.84*** (0.04)	0.86*** (0.04)	0.86*** (0.04)	0.78*** (0.04)	0.80*** (0.05)	0.80** (0.05)
Pervasive institutional environment	0.88*** (0.03)	0.88*** (0.04)	0.88*** (0.04)	0.92* (0.04)	1.05 (0.05)	1.06 (0.04)						
Arbitrary institutional environment							1.06 (0.06)	1.03 (0.06)	1.05 (0.07)	1.00 (0.07)	0.93 (0.07)	0.93 (0.07)

Fiscal freedom Index	1.12*** (0.01)	1.12*** (0.01)	1.12*** (0.01)	1.08*** (0.01)	1.16*** (0.01)	1.16*** (0.00)	1.11*** (0.01)	1.11*** (0.01)	1.11*** (0.01)	1.08*** (0.01)	1.15*** (0.02)	1.16*** (0.01)
Female management x Pervasive environment ***(H1)***			0.99 (0.11)	0.99 (0.11)	0.95 (0.12)	0.96 (0.11)						
Female management x Arbitrary environment ***(H2)***									0.91 (0.15)	0.85 (0.15)	0.98 (0.19)	0.96 (0.18)
Female management x Fiscal freedom Index ***(H3)***			1.03** (0.02)	1.04*** (0.02)	1.03** (0.02)	1.03** (0.02)			1.03* (0.03)	1.05* (0.03)	1.04* (0.04)	1.06* (0.05)
Female management x Firm Age (H4)						1.01** (0.05)						1.13*** (0.05)
Female management x Firm Age (squared) (H4)						0.99 (0.00)						0.99** (0.00)
Country characteristics												
Seats				1.04*** (0.00)	0.99 (0.00)	0.99 (0.00)				1.09** (0.01)	0.96*** (0.01)	0.96*** (0.01)
Discrimination				1.05 (0.11)	0.30*** (0.04)	0.30*** (0.03)				1.60** (0.31)	0.39*** (0.09)	0.40*** (0.09)
Maternity				0.84* (0.08)	0.35*** (0.04)	0.34*** (0.04)				1.19 (0.22)	0.52*** (0.11)	0.52*** (0.11)
FLPR				0.99*** (0.00)	1.00 (0.00)	1.00 (0.00)				0.98*** (0.00)	0.99* (0.01)	0.99* (0.01)
Economic development					2.30*** (0.39)	2.31*** (0.39)					1.68* (0.54)	1.75* (0.54)
Economic development x low income					0.44** (0.02)	0.44** (0.01)					0.45*** (0.04)	0.45*** (0.04)
Industry fixed effects	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
chi-squared	1691.88	1997.37	2001.97	3068.57	4589.57	4593.77	415.02	509.91	511.63	779.07	1157.10	1166.10
loglikelihood	-4604.01	-4451.26	-4448.96	-3915.66	-3155.16	-3153.0	-1433.00	-1385.56	-1384.70	-1250.98	-1061.96	-1057.01
pseudo R2	.15	.18	.18	.28	.42	.43	.12	.15	.15	.23	.35	.37

Note: Number of countries: 75. Number of firms in the full sample=12,412 , while number of firms in reduced sample=5,052. Level of statistical significance is * 0.10%; ** 0.05%. and *** 0.01%. Standard errors are in parenthesis and are robust for heteroskedasticity. Industry and year fixed – effects are included and suppressed to save space. Reference industry: Other manufacturing. Source: Authors calculation based on World Bank (2015, 2018), ILO (2018)

Figure 1: Predictive Margins of the effect of pervasive and arbitrary institutional environment as well as Fiscal Freedom on innovation propensity in women and men-led firms



Source: Authors calculations based on World Bank (2015, 2018), ILO (2018)

APPENDIX

Table A1: Averages for female management and corruption type, by country

Country in this study	Obs.	Share of Female Manager	Pervasive Corruption	Obs.	Share of Female Manager	Arbitrary Corruption
Afghanistan	57	0.04	0.41	36	0.06	0.16

Country in this study	Obs.	Share of Female Manager	Pervasive Corruption	Obs.	Share of Female Manager	Arbitrary Corruption
Albania	41	0.12	0.23	41	0.00	-0.54
Angola	41	0.15	0.48	14	0.07	-1.49
Argentina	402	0.06	-0.13	207	0.03	0.15
Armenia	107	0.04	-0.19	32	0.03	0.14
Azerbaijan	73	0.05	0.04	50	0.10	-0.09
Bangladesh	628	0.06	0.51	61	0.13	-1.28
Belarus	55	0.18	-0.24	18	0.11	0.42
Bhutan	46	0.11	-0.27	71	0.12	0.44
Bolivia	36	0.03	0.04	30	0.03	0.15
Bosnia	103	0.10	-0.28	35	0.09	0.38
Bulgaria	76	0.20	-0.35	34	0.07	0.40
Burkina Faso	46	0.20	-0.19	28	0.11	0.20
Burundi	27	0.15	-0.07	14	0.14	0.21
Cameroon	87	0.05	0.62	32	0.06	-0.82
Chile	446	0.09	-0.31	258	0.09	0.28
Colombia	274	0.17	-0.25	200	0.14	0.28
Costa Rica	67	0.12	-0.31	35	0.11	0.02
Croatia	33	0.18	-0.24	16	0.25	0.32
Czech Rep.	86	0.13	-0.33	23	0.22	0.38
Djibouti	11	0.27	-0.28	47	0.43	0.42
Dominica	31	0.13	-0.14	47	0.12	0.15
Ecuador	36	0.08	-0.33	30	0.10	0.37
Egypt	975	0.05	-0.18	65	0.03	-0.12
El Salvador	55	0.15	-0.33	50	0.15	0.37
Estonia	26	0.27	-0.33	28	0.25	-0.12
Ethiopia	93	0.14	-0.21	18	0.06	-0.34
Georgia	25	0.08	-0.31	25	0.20	0.38
Ghana	127	0.11	0.11	55	0.12	-0.02
Guatemala	150	0.15	-0.11	102	0.14	0.20
Honduras	66	0.11	-0.24	51	0.10	0.34
Hungary	77	0.09	-0.35	54	0.07	0.02
India	3,046	0.07	0.00	1,131	0.06	-0.16
Indonesia	191	0.14	0.10	78	0.18	-0.19
Israel	117	0.07	-0.34	20	0.15	0.40
Jamaica	32	0.06	-0.08	10	0.10	0.36
Kazakhstan	83	0.20	0.09	41	0.24	0.03
Kyrgyz Rep	114	0.22	0.41	38	0.16	-0.13
Lao PDR	53	0.25	0.15	49	0.24	-0.38

Country in this study	Obs.	Share of Female Manager	Pervasive Corruption	Obs.	Share of Female Manager	Arbitrary Corruption
Latvia	57	0.32	-0.32	17	0.24	0.33
Lebanon	65	0.03	0.28	14	0.07	-0.07
Lithuania	52	0.12	-0.28	22	0.14	0.27
Madagascar	33	0.18	-0.02	8	0.13	0.00
Malawi	73	0.16	-0.06	30	0.27	0.29
Mali	30	0.17	0.09	4	0.25	0.38
Mauritania	10	0.10	0.10	7	0.00	-0.54
Mauritius	6	0.12	-0.12	4	0.00	0.38
Mexico	404	0.08	-0.13	233	0.09	0.12
Moldova	92	0.24	-0.10	46	0.17	0.10
Mongolia	147	0.31	-0.01	82	0.32	-0.32
Montenegro	13	0.15	-0.19	8	0.25	0.39
Myanmar	160	0.21	0.62	121	0.20	-0.52
Nepal	233	0.08	0.18	49	0.07	0.25
Nicaragua	44	0.25	-0.12	29	0.28	0.15
Pakistan	166	0.03	0.27	16	0.00	-0.77
Panama	18	0.17	-0.41	7	0.00	0.39
Paraguay	36	0.11	0.12	23	0.04	-0.02
Peru	365	0.11	-0.19	228	0.10	0.14
Poland	72	0.14	-0.35	14	0.14	0.34
Romania	133	0.20	-0.23	42	0.10	0.37
Russia	219	0.18	0.02	119	0.14	-0.14
Senegal	48	0.08	-0.24	8	0.13	0.41
Serbia	95	0.19	-0.26	29	0.17	0.27
Slovak Rep.	49	0.10	-0.24	8	0.13	0.39
Slovenia	22	0.18	-0.38	6	0.17	0.40
Sri Lanka	126	0.14	-0.19	19	0.21	0.00
Tajikistan	82	0.07	0.39	40	0.10	-0.32
Tanzania	104	0.06	-0.22	42	0.10	0.19
Turkey	578	0.08	-0.24	232	0.10	0.24
Ukraine	310	0.20	0.21	117	0.19	-0.22
Uruguay	110	0.14	-0.30	58	0.16	0.29
Uzbekistan	83	0.07	-0.08	17	0.06	0.03
Venezuela	51	0.16	0.11	36	0.22	-0.06
Yemen	172	0.01	1.10	57	0.00	-1.22
Zambia	130	0.13	-0.13	80	0.13	0.20

Averages are calculated for the following variables related to testing our hypothesis. Source: World Bank (2015, 2018).