BLINDER-OAXACA APPROACH TO IDENTIFY INNOVATION DIFFERENCES IN TRANSITION COUNTRIES

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Blinder-Oaxaca Approach to Identify Innovation Differences in Transition Countries

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Abstract: *By the use of firm-level data coming from the Business Environment and Enterprise Performance Survey (BEEPS V) conducted in 2012–2014, this paper aims to investigate the sources of the possible gender ownership gap in innovativeness in a set of Transition economies. Through the Blinder-Oaxaca decomposition that allows us to define the factors responsible for the differences in the propensity to innovate between female-owned and male-owned firms, we find that the innovation disparity between firms with females among their owners and those having only male owners is mainly due to the differences in endowment effects. Tangible and intangible assets affect the innovation gap between the two groups of firms.*

Keywords: Blinder-Oaxaca decomposition; non-linear model; gender ownership; innovation gap; Transition Countries

Jel Codes : O32, J12, P23

I.INTRODUCTION

A sizable literature focused on innovation at the firm level considers gender as a neutral determinant. Gender gap in innovation adoptions by firms and, in particular, the role of female owners in the introduction of firm innovations are not well-understood as yet. The lack of studies on gender perspective in innovative processes could be explained by the unrecognizable role played by the people in innovation field.

To the best of our knowledge, there are no empirical studies that explore the role of gender ownership for innovation output activities for the Transition Countries. Therefore, this paper is an attempt to bridge the gap by exploiting firm-level data drawn from the Business Environment and Enterprise Performance Survey (BEEPS V) conducted in 2012–2014 jointly by the European Bank for Reconstruction and Development (EBRD) and the World Bank Group which includes information on several topics such as innovation, organization and management practices, employees, relations between enterprises and government, and other general information on firms.

In particular, our analysis is based on cross-section dataset covering the period between 2012 and 2014. We use data for 28 Transition countries. We employ the Blinder-Oaxaca decomposition that allows us to identify the factors responsible for the differences in the propensity to innovate between female-owned and male-owned firms. Our analysis is focused on the manufacturing sector characterized mainly by SME. SME in Transition Countries are far from the technology frontier and have several ways through which they could innovate. For firms in these countries, the innovative activities could reinforce those that already exist and be complementary. As well as catching up the technological gap, the innovative activity is the best possible strategy to be competitive and survive the growing pressure of developed countries that have a comparative advantage especially in the production of high skill-intensive goods.

The main finding obtained through the estimation of the probit model highlights that female owners have a significant and positive impact on the probability of introducing technological innovation in firms compared to only male-owned firms. Other traditional factors have a strong impact on technological innovation: the human capital, the sources of knowledge, the R&D activities, and the access to external financial resources. The results for Country Regions are also interesting because, differently from European former-USSR Countries, the Eurasian former-USSR Countries present a significant and negative association with innovation. In this geographical area, the long-

run transition process has changed the innovation policies.

Results are of particular interest when employing the extension of Oaxaca Blinder decomposition methodology. We found that the innovation gap between female-owned and male-owned firms is strongly significant. It is mainly due to the differences in endowment effects. Among the intangible assets, human capital and sources of knowledge are the main factors that affect the innovation gap between the two groups of firms. Both human capital and job training contribute positively to this gap, tertiary education negatively. Also, R&D activities and external knowledge contribute positively to the innovation differences. Concerning the tangible assets, the access to public subsidies has a significant and positive effect on the innovation gap. In contrast, the effect of the credit line is significant but negative. The other tangible factors explain the other portion of the innovation gap.

The remainder of the article is organized as follows. The next section provides the conceptual background to examine the innovation disparities between firms with female owners and male-owned firms. Section 3 describes the data and the variables. Section 4 outlines the econometric strategy, section 5 discusses the results. Finally, the last section provides discussion and conclusions.

II. THEORETICAL BACKGROUND

Up to now, the role played by gender in innovation literature has been modest and unrecognizable. A substantial part of studies on innovation has not considered the participants in the innovation processes, believing that gender was a neutral determinant factors (Fagerberg et al., 2005) or that innovators were invisible (Belghiti-Mahut et al., 2016).

Most of the innovation research at firm level has focused on the relationship between innovation and firms' performance (i.e. Latan et al., 2019; Wang and Wang, 2012); the different types of innovation and firms' competitive advantage (i.e. Arranz et al., 2019; Bowonder et al., 2010); the determinants of innovation and firm growth (i.e. Fazlıoğlu et al., 2019; Ahlin, 2014; Gupta et al., 2013; Aghion and Howitt,1992).

In the field of management and economics a growing literature has attempted to investigate the role of women in the firm highlighting: (i) the effect of women in the board of directors on the firm's financial and social performance (Boulouta, 2013;

Solakoglu, 2013; Carter et al., 2010); (ii) the network effects among different boards whose directors are women (Hodigere and Bilimoria, 2015; Terjesen et al., 2009; Hillman et al., 2007); (iii) the impact of women on corporate governance (Adams and Ferreira, 2009); (iv) the female influence on the firms' acquisition decisions (Levi et al., 2015) and (v) the relationship between gender diversity in research and development (R&D) team or management and organizational performance (Triana et al., 2019; Wikhamn and Wikhamn, 2019; Christiansen et al. 2017; Nakagawa, 2015; Smith et al., 2006) or firm's innovation efficiency (Xie et al., 2020).

Several works employ the Shannon-Weaver entropy index[1] or the Blau index[2] to capture the gender diversity and use it to study the effect on innovation performance (Gallego and Gutierrez, 2018; Fernandez 2015; Teruel et al., 2015; Østergaard et al.,2011) or to analyze the relationships between R&D teams and innovation (Xie et al., 2020; Dai et al., 2019; Garcia Martinez et al.,2016; De Saà-Peréz et al., 2015; Diaz-Garcìa et al.,2013).

The study carried out by Østergaard et al. (2011) on the relationship between gender diversity and firm innovation deserves attention. Using information from a sample of 1,600 Danish manufacturing and service firms between 2003 and 2005 coming from two data sources, they apply a logistic regression model and show a positive association between employee diversity in gender and firm innovation. In other words, they find that the more innovative firms have a more balanced gender composition.

Diaz-Garcìa et al. (2013) use CIS data and R&D activities statistics on 4,277 Spanish firms in 2007 in industrial (83%) and service sectors (17%) and employ two logistic binary regressions. Results confirm that gender diversity in the organization

[1] The Shannon index (H) is employed to describe groups diversity in a community. This index considers both abundance and evenness of the groups present. The Shannon index is expressed as follows:

$$H = -\sum_{i=1}^{R} p_i ln p_i$$

Where R is the number of categories and p_i is the proportion of groups i relative to the total number of p_i *and* lnp_i is the natural logarithm of p_i.

[2] The Blau index (D) is an index of heterogeneity and it is measured as follows:

$$D = 1 - \sum_{i=1}^{k} p_i^2$$

where K is the number of categories and p_i^2 is the square of the proportion of groups i relative to the total number of p_i.

and the difference in skills, knowledge and experience strongly support the team to be more innovative.

In addition, Gallego and Gutierrez (2018) focus on 17,055 Colombian manufacturing firms in the period 2011-2014. They find that innovation activities are associated positively with the number of women employed. They also underline a positive effect of gender diversity on technological rather than non-technological innovation, with a significant impact on the technological type of innovation.

In line with previous study, Dai et al. (2019), exploiting a sample of 300 new Chinese firms operating during the year 2018 and applying an OLS regression, show that the presence of women increases the knowledge differences and the firm innovation performance mainly when it is combined with the male entrepreneurship.

Also, Teruel et al. (2015) investigate the effect of gender diversity and firm dimension on different types of innovation activities, employing a multivariate probit model. Considering a panel data of 5392 Spanish firms in manufacturing and service sectors in the period 2007-2008, they find that firm size is weakly relevant when the analysis is focused on the relationship between gender and innovation.

The study of Ritter-Hayashi et al. (2019) is the only one that has recently examined the relationship between gender diversity and innovation comparing managers and owners both in developed and developing countries. Exploiting jointly the World Bank's Enterprise Survey (ES) and the Women's Economic Opportunity Index (WEOI) for a sample of 18,547 firms in 15 countries of Africa, Middle East and South Asia in the period 2013-2014 and applying a logit regression model, the authors show that female top managers as well as gender diversity among firm's owners promote a higher innovation firm activity.

Overall, although the literature on gender diversity is wide, only few papers focus on the relationship between innovation and female top managers or analyze the difference between female managers and female owners.

Dezso and Ross (2012) investigate the effect of female representation in top management on firm performance and innovation by using S&P's CompuStat database on the top management teams on a sample of 1,500 public U.S in the period 1992-2006. The empirical evidence indicates a positive and significant relationship between female representation in top management and firm performance only when the firm's strategy is focused on innovation.

Becic and Vojinic (2018) study the relationship between female top manager and innovation in CEECS' firms. Using the firm-level data from BEEPS in the period 2012-2014 for a sample of 3,519 firms in 11 countries and applying a logistic binary regression, they find that, on average, the firm innovation activities are lower when women are top managers.

Employing a logistic regression model, Dohse et al. (2019) compare the role of female managers and female owners in the introduction of product innovation in emerging and developing countries. They exploit the World Bank's Enterprise Survey for a sample of 66,887 firms in 100 countries during the period 2010-2016, and find that female owners rather than female managers are more prone to introduce innovation.

Finally, focusing on the Transition Countries, few analyses attempt to explain the innovation gap between male and female owners at firm's level. Popovic Pantic (2014) conducts a descriptive study on a sample of 22 Serbian small and medium firms during the year 2010. Employing the IMP rove methodology that includes five dimensions of innovation[3], she emphasizes the female capacity to improve incremental innovation even if this capacity strongly depends on financial and human resources.

The study of Sirec and Mocnik (2015) examines the innovation activities and the gender dimensions of owner-managers of firms in 8 south-eastern European countries (SeECs). Using the Global Entrepreneurship Monitor (GEM) data covering the period 2003 – 2008 on a sample of 1,889 males and 1,071 females and applying a binary logistic regression model, they show that significant relationships exist between the innovative activity and the main predictors (education, international orientation and firm growth aspiration) that are different between the two genders.

Yet, Hozer-Kocmiel et al. (2017) carried out 102 qualitative pilot surveys on women who conducted their business activities in small and medium firms in the tourism and creative sectors in 5 Baltic Sea countries during the year 2015. They examine the role of gender in innovation and find that the creative industry is more innovative than the tourism sector.

In contrast with the previous literature, our analysis is the first to employ the Blinder-Oaxaca decomposition to identify the factors responsible for the differences in

[3] The five dimensions are: innovation strategy, organization and innovation culture, innovation life cycle process and other factors that promote management innovation.

the propensity to innovate between female-owned firms and male-owned firms in 28 Transition Countries.

III.DATA COLLECTION AND VARIABLES

As noted above, we exploit firm-level data gathered from the Fifth Round of the Business Environment and Enterprise Performance Survey (BEEPS V) conducted in 2012–2014 jointly by the European Bank for Reconstruction and Development (EBRD) and the World Bank Group. This is a firm-level survey derived from face-to-face interviews with managers. The survey consists of 17 sections that provide several pieces of information on: (i) the innovation behavior of firms, (ii) innovative activities, organization practices, management and employees and (iii) other general information on firms. The survey has a wide sectorial coverage of the non-agricultural economy including all manufacturing sectors, construction, services, transport, storage, communication and IT. The survey contains a representative sample of firms that have been chosen using the stratified sample methodology, these strata depending on the region, sector and dimension of the firm. BEEPS survey represents a unique opportunity that allows to examine and compare factors that affect innovation for firms across transition countries. This survey permits us to also investigate the factors that influence the innovation activities across firms within a given country. It is based on data from about 17,000 firms from 32 countries of Eastern Europe and Central Asia. This group of countries shares a similar institutional background, in fact, all the countries considered, except for Turkey, applied the principles of a centrally planned economy for several decades. According to their level of innovative activity it is possible to distinguish these countries in: (i) innovation followers and (ii) modest innovators (Tomaszewski and Świadek, 2017). The sample used in our analysis consists of 5,149 firms from 28 selected transition countries and 2,097 firms that have adopted a technological innovation. These transition economies have experienced an increase in their technological capabilities. In addition, these countries have introduced several policy measures to improve the level of competition and to make less concentrated market structures (Friesenbichler et al., 2014).

Innovation is our dependent variable and we use a self-reported measure of innovation developed according to the Community Innovation Survey (CIS) (Brouwer

and Kleinknecht, 1996). In particular, we consider the technological innovation, namely new products and processes, and significant technological changes of products and processes. Therefore, based on information provided by the BEEPS survey, we construct our dependent variable, which is a binary variable equal to 1 if the firm, in the last three years, has introduced a technological innovation, and 0 otherwise. The main explanatory variable of interest is the firm's ownership that assumes a value equal to 1 if the owner of the firm is female, and 0 if he is male. Using this variable in our estimation, we verify whether female owners with respect to their male counterparts are more prone to adopt an innovation. Control variables are included in the analysis to account for other factors that are likely to influence firms' innovation activities. To capture the impact of human capital we consider: (i) the percentage of firm's permanent full-time workers with a university degree; (ii) a dummy variable that shows if the firm offered, during the last year, formal training to its skilled workers and finally (iii) the years that the top manager spent in that specific sector. To consider firms' financial resources, we observe (i) the access to a line of credit or a loan from a financial institution and (ii) the receipt of financial subsidies from the national, regional or local governments or the European Union. To capture the internal capacity of a firm to generate knowledge, we include a binary variable for R&D which is 1 if the firm, in the last three years, has spent on research and development activities, or 0 otherwise. Since only a few firms are able to support their competitiveness and innovation by focusing exclusively on internal sources of knowledge, it is important to note the role played by knowledge from external sources. In this regard, we introduce a dummy variable equal to 1 if a firm, over the last three years, has used resources to purchase external knowledge from other businesses or organizations, or to 0.

Other characteristics considered are: (i) size, an ordered variable that is equal to 1 for small firms (less than or equal to 19 employees), 2 for medium firms (20–99 employees) and 3 for large firms (more than 100 employees); (ii) the geographic dimension of markets; (iii) whether the firm is an independent economic entity (taking the value of 1) or part of a corporate group (taking 0).

To test whether ownership influences the technological innovation output, we use an ordinal categorical variable that takes into account how the firm was founded. To evaluate if female-intensity firms are more innovative, we include a variable that reflects the share of female workers in full-time employment. We also employ a sector

variable; firms are aggregated according to the level of their technological intensity (high, medium and low-tech) using the Eurostat classification based on NACE Rev. 2 at 2-digit level. Finally, we divide our sample into four different geographical regions (European Former-USSR Countries, Former Yugoslavian Countries and Albania, Eurasian Former-USSR Countries and Central European countries) to check out the regional differences.

Table A2 in the Appendix contains the description of variables included to account for factors that could affect the propensity of a firm to adopt an innovation. Table 1 reports the descriptive statistics.

Table 1. Descriptive statistics of variables

Name of variable	Obs	Proportion	Mean	Std. Err.	Std.Dev
Technological Innovation	5028	0.41		0.007	
Firm ownership	5058	0.33		0.007	
Firm Dimension	5149				
Small Firms		0.45		0.007	
Medium Firms		0.39		0.007	
Large Firms		0.15		0.005	
Affiliation	5149	0.07		0.004	
Human Capital					
Education	4812		31.51		28.59
Training Programs	5003	0.34		0.007	
Experience Top Manager	4930		16.84		10.26
Financial Resources					
Financial Subsidies	5009	0.11		0.004	
Line of Credit	4997	0.35		0.007	
Research and Development	5023	0.15		0.005	
Knowledge	3174	0.17		0.007	
Sales Market	5019				
More National Sales		0.81		0.005	
National and International Sales		0.11		0.004	
More International Sales		0.08		0.004	
Firm Creation	5108				
Privatization of a state-owned firm		0.15		0.005	
Originally private, from time of start up		0.79		0.005	
Private subsidiary of a formerly state-owned firm		0.02		0.002	
Joint venture with foreign partner(s)		0.02		0.002	
State-owned firm		0.02		0.002	
Female Workers	4168		39.30		29.30
Industry Sectors					
Low Tech	4761	0.46		0.007	
Medium Tech		0.45		0.007	
High Tech		0.09		0.004	
Country Regions					
European Former-USSR Countries	5058	0.40		0.006	
Central European Countries		0.14		0.005	
Former Yugoslavian Countries and Albania		0.16		0.005	
Eurasian Former- USSR Countries		0.30		0.006	

41% of sampled firms perform technological innovations and 33% get a female owner. On average, 36% of people working in the manufacturing sector are women, 32% of workforce has a tertiary education, while the industry-specific experience of managers is about 17 years. Job-training programs are offered to employees by 34% of sampled firms. 15% of firms spends in R&D activities and only 17% invests resources for the acquisition of external knowledge. Yet, 11% gains access to financial subsidies, while 35% of firms have the availability of credit line. The data also show that only 9% of sampled firms is engaged in production of high skill-intensive goods and about 80% sells their products for the most part on the national markets. Finally, 79% are private firms and 80% is of small-medium size.

Table 2 displays the differences, in mean and proportions for all variables used in this analysis. To test if the differences are statistically significant, we perform the Student's *t*-test[4] used when two independent groups are compared.

Table 2. Overall sample characteristics

Variable	N.of Obs	Overall sample		
		Men Owners	Women Owners	Differences
Technological Innovation	5028	0.383	0.457	-0.074***
Small Firms	5058	0.459	0.460	-0.001
Medium Firms	5058	0.395	0.386	0.009
Large Firms	5058	0.146	0.154	-0.008
Female Workers	4104	4.609	4.610	-0.001
Affiliation	5058	0.070	.071	-.001
Education	4812	4.858	4.857	0.001
Training Programs	5003	0.323	0.376	-0.053***
Experience Top Manager	4930	4.775	4.761	-0.006**
Financial Subsidies	5009	0.104	0.134	-0.030***
Line of Credit	4997	0.353	0.360	-0.007
Research and Development	5023	0.134	0.169	-0.035***
Knowledge	3174	0.164	0.168	-0.004
More National Sales	5019	0.815	0.0808	0.009
National and International Sales	5019	0.107	0.106	0.001
More International Sales	5019	0.075	0.086	-0.011
Privatization of a state-owned firm	5020	0.123	0.194	-0.071***
Originally private, from time of start up	5020	0.820	0.738	0.082***
Private subsidiary of a formerly state-owned firm	5020	0.021	0.027	-0.006
Joint venture with foreign partner(s)	5020	0.023	0.016	0.007
State-owned firm	5020	0.011	0.026	-0.015***
Low Tech	4761	0.428	0.540	-0.112***
Medium Tech	4761	0.477	0.389	0.088***
High Tech	4761	0.095	0.071	0.024***
European Former-USSR Countries	5058	0.405	0.401	0.004
Central European Countries	5058	0.127	0.172	-0.045***
Former Yugoslavian Countries and Albania	5058	0.164	0.141	0.023**
Eurasian Former- USSR Countries	5058	0.305	0.287	0.018
N		3362	1666	

[4] Student's *t*-test is a parametric procedure that assumes normality of the data and equality of variances across comparison groups. This analysis is performed on log-transformed data and compares the means or proportions of the groups.

Variable	N.of Obs	Overall sample		
		Men Owners	Women Owners	Differences

*,**,***. Statistically significant at the 10%, 5% and 1% level respectively based on two-tailed t-test. Mean and proportions for continuous and dummy variables respectively.

The results highlight a significant disadvantage of male owners in technological innovation activities so far as to offer formal training to its skilled workers and to obtain financial subsidies from the national, regional or local governments or the European Union. The findings also show significant differences, between firms with female owners and those wholly male owned, in R&D activities and in the acquisition of external knowledge from other businesses or organizations. Finally, the only advantage that male owners have over their female counterparts is pointed out with reference to the technological intensity of the sectors.

To sum up, the difference in innovative activities between the firms with females amongst owners and those in which they are not present is strongly statistically significant, so we decide to perform the decomposition in order to understand: (i) the elements that could explain this gap and (ii) which one impacts more.

IV. EMPIRICAL STRATEGY

To identify gender innovation difference in transition countries, this paper employs an application of the Blinder (1973) and Oaxaca (1973) decomposition principle. Blinder (1973) and Oaxaca (1973) developed a decomposition methodology to investigate the source of gender wage gap. According to this decomposition, gender pay gap is the sum of: (i) the differences in the average observed characteristics of the two groups and (ii) the differences in the coefficient estimates. The linear Blinder–Oaxaca decomposition has been revised to be also applied to non-linear estimation model (Bauer and Sinning, 2008; Fairlie, 1999, 2005; Yun 2000, 2004, 2005; Powers et al., 2009).

Therefore, we employ a multivariate nonlinear decomposition methodology to observe the contribution of each covariate to the difference in innovation between two groups: female-owned firms and male-owned ones in a sample of Transition Countries. This approach is an extension of the Blinder-Oaxaca technique developed by Powers et al. (2009) for non-linear dependent variables that allows us to examine differences not only between two groups but also between two points in time. This method requires different steps: (i) model specification and regression; (ii) decomposition of innovation

gaps according to the Blinder-Oaxaca approach; (iii) the contribution of a variable k on the total innovation gap between two groups according to the approach proposed by Yun (2004). For the two groups the probability to innovate can be estimated as follows:

$$I\text{ij}= \Phi\left[X_{ij}\beta_j\right]$$

I_{ij} is the dependent variables, it is equal to 1 if a firm i of the group j (j = A, B) has adopted a technological innovation, 0 otherwise.

X_{ij} is the vector of the observed characteristics of the firm i in a group j and $\Phi(.)$ is the cumulative function of a normal distribution with zero mean and variance σ^2[5]. Using the maximum likelihood method, we estimate coefficients that allow us to calculate the predicted probability and determine the marginal effects representing the change in predicted probability to innovate. To estimate the difference in gender innovation and the main determinants that influence this gap, we assume, a priori, that the yields of firm characteristics are different depending on the male and female owners. The Oaxaca (1973) and Blinder (1973) approach and its extensions suggest employing the average of the estimated characteristics and coefficients in order to conduct the decomposition. Therefore, the innovation gap between two groups of interest is the sum of two components:

$$I_A - I_B = \left[\overline{\Phi\left(X_A\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_A\right)}\right] + \left[\overline{\Phi\left(X_B\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_B\right)}\right]$$

(i) a component explained by the difference in observable characteristics:

$$Exp = \left[\overline{\Phi\left(X_A\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_A\right)}\right]$$

(ii) an unexplained component related to the difference in coefficients for interest groups, A and B:

$$NExp = \left[\overline{\Phi\left(X_B\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_B\right)}\right]$$

Oaxaca and Ransom (1999) have shown a problem of identification with respect to the interpretation of coefficients of qualitative variables when the regression has a class of qualitative variables used as a reference variable. In this case, the regression results depend on the reference variable chosen.

[5] It should be noted that there may be unobserved heterogeneity in the characteristics of firms across groups and that this unobserved heterogeneity could influence the average probability of innovation. However, since we use cross-sectional data, the model does not allow to consider this phenomenon.

To overcome this problem, Yun (2003) proposes an approach to standardize the regression equation[6]. This methodology has two main advantages: (i) it does not change in relation to the reference category when assessing the contribution of dichotomous variables to the effects of coefficients and (ii) either the effects of the characteristics or the contributions of the continuous variables to the effects of the coefficients remain unchanged. Therefore, the model can be written as follows:

$$\hat{I}_i = F\left(\hat{\alpha} + \sum_{i=1}^{L} X_i \hat{\delta}_i + \sum_{m=1}^{M} \sum_{k_m=1}^{K_m} D_{mk_m} \hat{\beta}_{mk_m} \right)$$

Where X are the L continuous variables and D represents the M qualitative variables. In this equation the m^{th} variable has k_m categories.
As a result, the normalized equation is:

$$\hat{I}_i^* = F\left(\hat{\alpha}^* + \sum_{i=1}^{L} X_i \hat{\delta}_i^{\,*} + \sum_{m=1}^{M} \sum_{k_m=1}^{K_m} D_{mk_m} \hat{\beta}^*_{mk_m} \right)$$

Where the intercept parameters of continuous and dichotomous variables are respectively:

$$\hat{\alpha}^* = \hat{\alpha} + \sum_{m=1}^{M} \bar{\hat{\beta}}_m;$$

$$\hat{\delta}_i^{\,*} = \hat{\delta},\ i=1,\ldots,L$$

$$\hat{\beta}^*_{mk_m} = \hat{\beta}_{mk_m} - \bar{\hat{\beta}}_m, \quad k_m = 1, \ldots . k_m \text{ and } m = 1, \ldots, M$$

In this way we can perform the decomposition to identify the effects of the characteristics and coefficients for each category, including the reference group in the original equation. According to Even and Macpherson (1990, 1993) the contribution of an explanatory variable k in the *Exp* component is given by:

$$Exp_k = \left[\overline{\Phi\left(X_A \hat{\beta}_B\right)} - \overline{\Phi\left(X_B \hat{\beta}_B\right)} \right] \left[\frac{\left(\bar{X}_A^k - \bar{X}_B^k\right)\hat{\beta}_A^k}{\left(\bar{X}_A - \bar{X}_B\right)\hat{\beta}_A} \right]$$

where $\bar{X}_j^k$ is the mean of the observations of variable k in the group j.

[6] The problem of identification concerns only the detailed effect of the coefficients.

A generalization of this result is proposed by Yun (2004) to measure the contribution of a variable k to the total innovation gap between groups A and B. Thus, the innovation gap between two groups can be decomposed as follows:

$$I_A - I_B = \sum_{k=1}^{K} W_{\Delta X}^{k} \left[\overline{\Phi\left(X_A\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_A\right)}\right] + \sum_{k=1}^{K} W_{\Delta\bar{\beta}}^{k} \left[\overline{\Phi\left(X_B\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_B\right)}\right],$$

where

$$W_{\Delta X}^{k} = \left[\frac{\left(\bar{X}_A^k - \bar{X}_B^k\right)\hat{\beta}_A^k}{\left(\bar{X}_A - \bar{X}_B\right)\hat{\beta}_A}\right], W_{\Delta\hat{\bar{\beta}}}^{k} = \frac{\bar{X}_B^k\left(\hat{\beta}_A^k - \hat{\beta}_B^k\right)}{X_B\left(\hat{\beta}_A - \hat{\beta}_B\right)}, and \sum_{k=1}^{K} W_{\Delta X}^{k} = \sum_{k=1}^{K} W_{\Delta\hat{\bar{\beta}}}^{k} = 1$$

Lastly, it is possible to test the statistical significance of the effects of coefficients and characteristics using the delta method proposed by Yun (2005). In fact:

$$C_k = W_{\Delta X}^{k} \left[\overline{\Phi\left(X_A\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_A\right)}\right] \; and \; D_k = W_{A\hat{\bar{\beta}}}^{k} \sum_{1}^{K} W_{\Delta\bar{\beta}}^{k} \left[\overline{\Phi\left(X_B\hat{\beta}_A\right)} - \Phi\overline{\left(X_B\hat{\beta}_B\right)}\right]$$

Represent, respectively, the effects of the characteristics and coefficients of the variable k. For C_k and D_k the asymptotic variances are:

$$\sigma_{C_k}^2 = \frac{\partial C_k}{\partial \beta_A'} \sum (\beta_A) \frac{\partial C_k'}{\partial \beta_A} \; and \; \sigma_{D_k}^2 = \frac{\partial D_k}{\partial \beta_A'} \sum (\beta_A) \frac{\partial D_k'}{\partial \beta_A} + \frac{\partial D_k}{\partial \beta_B'} \sum (\beta_B) \frac{\partial D_k'}{\partial \beta_B}$$

where $\frac{\partial C_k}{\partial \beta_j'}$ and $\frac{\partial D_k}{\partial \beta_j'}$ are gradient vectors of order (*1xK*) and $\sum\left(\beta_j\right)$ is the asymptotic covariance matrix of β for the group j.

This matrix is obtained by the probit model regression. Yun (2005) shows that under the null hypothesis of nullity of the coefficients of the variable k, namely C_k=0 and $D_k = 0$, the statistical tests $t_{c_k} = \frac{C_k}{\sigma_{C_k}}$ and $t_{c_k} = \frac{D_k}{\sigma_{D_k}}$ are distributed according to the normal distribution.

V. ECONOMETRIC RESULTS

First, we examine the factors that affect firms' innovation employing a probit model that allows us to identify the determinants of a firm's decision to innovate. We choose the probit model for the following reasons: (i) the dependent variable is dichotomous and (ii) it provides a better fit of the data and finally (iii) it represents the starting point for the decomposition allowing, in advance, to highlight the determinants of innovation

activities. Then, we conduct the multivariate decomposition methodology to explain the gender innovation gap in transition countries. This approach distinguishes the innovation differences between enterprises with female and male owners into a part that accounts for the disparities of observed covariates and a part that cannot be explained by observed disparities in the covariates.

Table 3 displays the results of the probit model. The table reports both coefficients and marginal effects, the latter leads to the conclusion on the actual probabilities of specific outcome.

Table 3. Estimated coefficients and marginal effects

	Technological Innovation			
Name of variable				
	Coeff.	Std. Err	dy/dx	Std. Err
Gender Firm Ownership- Ref. Male	0.104*	(0.061)	0.033*	(0.021)
Firm Dimension - *Ref. Small Firms*				
Medium Firms	-0.551***	(0.066)	-0.178***	(0.021)
Large Firms	-0.371***	(0.091)	-0.117***	(0.029)
Female Workers	0.219**	(0.113)	0.071**	(0.036)
Affiliation	-0.034	(0.110)	-0.011	(0.035)
Education	0.003***	(0.001)	0.001***	(0.000)
Training Programs	0.254***	(0.061)	0.083***	(0.019)
Experience Top Manager	0.005*	(0.003)	0.002*	(0.001)
Financial Subsidies	0.271***	(0.089)	0.087***	(0.028)
Line of Credit	0.140**	(0.061)	0.045**	(0.021)
Research and Development	0.705***	(0.079)	0.227***	(0.024)
Knowledge	0.365***	(0.084)	0.118***	(0.027)
Market Sales -*Ref. More National Sales*				
National and International Sales	-0.030	(0.066)	-0.010	(0.028)
More International Sales	-0.358***	(0.092)	-0.115***	(0.029)
Firm Creation- *Ref. Privatization of a state-owned firm*				
Originally private, from time of start up	0.209**	(0.081)	0.068**	(0.027)
Private subsidiary of a formerly state-owned firm	0.133	(0.198)	0.044	(0.065)
Joint venture with foreign partner(s)	0.222	(0.185)	0.073	(0.059)
State-owned firm	0.360*	(0.203)	0.116*	(0.062)
Industry Sectors- *Ref. Low Tech*				
Medium Tech	-0.003	(0.066)	-0.001	(0.022)
High Tech	0.171	(0.119)	0.054	(0.037)
Country Regions - *Ref. European Former-USSR Countries*				
Central European Countries	-0.129	(0.091)	-0.041	(0.029)
Former Yugoslavian Countries and Albania	-0.137	(0.092)	-0.044	(0.030)
Eurasian Former- USSR Countries	-0.540***	(0.076)	-0.182	(0.026)
Constant	0.028	(0.142)		
Predicted probability to innovate				
	Nb Firms: 2339			
	Prob>F = 0.0000			

Standard errors in parentheses ***p<0.01, **p<0.05, *p<0.10

The main results confirm the role of gender ownership on the firm's propensity to innovate. Firms with female owners have a significant and positive impact on the probability of introducing technological innovation. Females among the owners could lead to an increase in innovation of more than 3% compared to only male-owned firms.

Other results highlight that education and firms' training programs have a

positive effect on the decision to adopt a technological innovation. An increase of one percentage point in the tertiary-educated workers produces an increase equal to 0.1% of the probability to innovate since education improves technical expertise, promotes creativity, and facilitates the use of tools and equipment. Yet, firms whose employees receive training programs have 8% of chance of implementing innovation. This means that training programs provide workers with the skills needed to enhance the firms' innovative capacity.

Moreover, a top manager with experience has a positive effect on the propensity to innovate. By increasing their years of experience, the top manager strengthens his innovation capabilities. It follows that, for each additional year of experience, the innovative capacity of the firm increases by 0.2%. The role played by worker's diversity in a firm is also crucial. The presence of female employees and managers has a positive and significant effect on firm's innovation. In this regard, a 1% increase in female workers leads to an increase of 7% in innovation. The female employees and managers in the firm should increase the interaction between different types of knowledge and skills with a consequent growth of the firm's knowledge base for an innovative activity.

Looking at the firm size, we find that large and medium firms show a significant and negative impact on innovation performance even if larger firms have a higher gender diversity potential. By crossing this result with the owned-status of firm, we can remark that the private firms have a 6.8% propensity to influence innovation activities with respect to the firms following the privatization of a state-owned firm. Then, the plausible interpretation is that the State's influence on public firms is still crucial in our sample countries and the firms' privatization process is not yet completed.

Our findings also confirm that firms' external financial resources are significant for the firm performance to fund artefacts, prototypes, and patents. Firms receiving financial subsidies are 9% more responsive to adopt an innovation than those without any kind of subsidy. Our findings suggest that public subsidies have additional effects on firms' innovation activities with respect to private funding. Among them, the access to a line of credit gives firms an innovation probability of more than 4% with respect to those that do not have this access. This implies that, despite financial constraints and restrictions, it is easier for the firms to obtain a line of credit or a loan from a financial institution.

Needless to say, R&D activities are positively related to the probability of

introducing firms' innovation. The chance of innovating for firms that invest in R&D is 23% more reactive than those which prefer not to allocate resources to in-house or external R&D activities. Another source of innovation is the acquisition of external knowledge from other firms, university, and research institutes. Firms that gain external experience and knowledge are 11.8% more sensitive to innovate than those that have not focused on the acquisition of external knowledge. It follows that external knowledge is an additional and complementary input for the development and improvement of the firms' innovation activities.

Moving on to the geographical area where the firms trade their products, our findings show that firms selling more on the international markets are 11.5% less likely to have innovation, as against firms that sell mainly on national markets. This would suggest that the exporting firms are less competitive on the international market.

With reference to the Country Regions, the probability of developing innovation decreases significantly (18%) for Eurasian former-USSR Countries if compared to European former-USSR Countries. Probably the result depends on the innovation policies adopted in this geographical area that has been engaged in a long-run transition process passing from a planned economic system to a market economy.

Table 4 displays the results obtained using the extension of the Oaxaca-Blinder method developed by Powers et al. (2009). Especially, it shows the contribution of endowment and coefficient effects in explaining the innovation gap between enterprise with female and male owners. A negative (positive) contribution indicates that the determinant was narrowing (increasing) the gap between the two groups. First, the innovation gap between the two categories of firms is the sum of the aggregate effect of endowments and coefficients. This gap is strongly significant and equal to 5.7%. About 43% of this innovation gap is attributable to the differences in endowment effects that are strongly significant. Although not statistically significant, the gap in technological innovation explained by the differences in unobservable factors is equal to 57%.

This result assumes that if the differences in the characteristics of firms with female owners and male-owned firms were to disappear, the innovation gap observed would be narrowed to 2.4%. Looking at the results in more details, the gap in innovation can be attributed mainly to the human capital and sources of knowledge that represent 11.45% and 16.35% of endowment effect, respectively.

The different forms of human capital impact in an opposite way on the innovation

gap. The job-training programs contribute to this gap with a share of 12%. In other words, if the firms of two groups provided the same training to their workers the difference in innovation could be down by 0.7%. At the same time, an increase in the innovation gap could be experienced equalizing the percentage of permanent full-time workers with a university degree in the firms with female owners and those wholly owned males.

R&D expenditure and external knowledge jointly influence the innovation gap between the two groups. This means that if the firms allocated an equal amount of resources in R&D and purchased knowledge from other businesses or organizations the difference in innovation would reduce by 0.8% and 0.1%, respectively.

The access to financial resources has a different effect on the innovation gap. The access to the financial subsidies is found to explain the innovation differential of 3.25%. This finding reveals that if the firms with male owners enjoyed the same financial subsidies as the enterprises with female owners the gap in the probability of innovating could be reduced by 0.2%. In contrast, the effect of characteristic associated with availability of credit line is significant and negative. It follows that the gap in innovation could increase significantly by 0.1% if the two types of firm had access to these financial funds. When we look at firm characteristics, we find that firm size accounts for nearly 3% of the explained in innovation differential. In particular, small firms account for 1.89% of the gap, which means that this effect is greater in such firms.

Moving on to the process of setting up a firm and to the geographical scope of the market, since at the aggregate level the effect of the endowments is not significant, we focus our attention only on firms that have been privatized and those that sell more on the national market. For both types of firm, the variation in term of endowments is significant and negative. Thus, both encourage a reduction in the gap observed.

Finally, going back to the areas where firms undertake their activities, we find that firms established in the former Eurasian region boost a significant increase of innovation gap between the two types of firms equal to 0.1%.

Table 4. Probit decomposition of technological innovation gap

Technological Innovation	Estimate	Std.Err.	Percent
Explained: due to the difference in characteristics	0.024***	(0.009)	42.53
Unexplained: due to the difference in coefficients	0.033	(0.021)	57.47
Raw Difference	0.057***	(0.019)	
Due to Difference in Characteristics (E)			
Technological Innovation	**Estimate**	**Std.Err.**	**Percent**
Human Capital			11.45
Education	-0.001***	(0.000)	-1.56
Top Manager Experience	0.001	(0.001)	0.99
Program Training	0.007***	(0.002)	12.02
Sources of knowledge			16.35
Research & Development	0.008***	(0.002)	14.65
Knowledge	0.001*	(0.001)	1.70
Financial Resources			1.63
Financial Subsidies	0.002**	(0.001)	3.25
Line of Credit	-0.001**	(0.000)	-1.62
Affiliation	0.000	(0.000)	0.42
Female Workers	0.009	(0.007)	15.57
Firm Dimension			2.91
Small Firms	0.001***	(0.000)	1.89
Medium Firms	0.000**	(0.000)	0.87
Large Firms	0.000	(0.000)	0.15
Firm Creation			-3.43
Privatization of a state-owned firm	-0.007*	-0.003	-11.71
Originally private, from time of start up	0.001	(0.004)	1.25
Private subsidiary of a formerly state-owned firm	0.000	(0.001)	0.86
Joint venture with foreign partner(s)	0.001	(0.001)	2.40
State-owned firm	0.002	(0.001)	3.77
Market Sales			-3.36
More National Sales	-0.001***	(0.000)	-2.43
National and International Sales	0.000	(0.000)	0.40
More International Sales	-0.001	(0.001)	-1.33
Industry Sector			-1.63
Low Tech	0.000	(0.003)	0.83
Medium Tech	-0.002	(0.002)	-4.32
High Tech	0.001	(0.001)	1.86
Country Region			2.63
European Former-USSR Countries	-0.001	(0.001)	-1.61
Central European Countries	0.001	(0.002)	2.60
Former Yugoslavian Countries and Albania	-0.000	(0.000)	-0.62
Eurasian Former- USSR Countries	0.001***	(0.000)	2.26
Due to Difference in Coefficients (C)			
Technological Innovation	**Estimate**	**Std.Err.**	**Percent**
Human Capital			86.79
Education	0.055	(0.037)	95.46
Top Manager Experience	-0.022	(0.048)	-39.14
Program Training	0.017	(0.023)	30.47
Sources of knowledge			-56.02
Research & Development	-0.014	(0.019)	-25.20
Knowledge	-0.018	(0.015)	-30.82
Financial Resources			55.48

Technological Innovation	Estimate	Std.Err.	Percent
Financial Subsidies	0.004	(0.011)	6.52
Line of Credit	0.028	(0.027)	48.96
Affiliation	-0.010	(0.009)	-17.26
Female Workers	0.002	(0.038)	2.96
Firm Dimension			22.82
Small Firms	-0.013	(0.016)	-22.50
Medium Firms	0.034	(0.021)	58.82
Large Firms	-0.008	(0.011)	-13.50
Firm Creation			-98.07
Privatization of a state-owned firm	-0.009	(0.011)	-15.11
Originally private, from time of start up	-0.046	(0.060)	-80.39
Private subsidiary of a formerly state-owned firm	0.004	(0.003)	7.00
Joint venture with foreign partner(s)	-0.008	(0.006)	-14.42
State-owned firm	0.003	(0.002)	4.85
Market Sales			-30.05
More National Sales	-0.017	(0.016)	-29.03
National and International Sales	-0.012	(0.009)	-21.18
More International Sales	0.012	(0.008)	20.16
Industry Sector			97.63
Low Tech	0.020	(0.023)	34.88
Medium Tech	-0.012	(0.009)	88.40
High Tech	0.012	(0.008)	-25.65
Country Region			-20.33
European Former-USSR Countries	-0.029	(0.021)	-49.14
Central European Countries	0.001	(0.009)	1.15
Former Yugoslavian Countries and Albania	0.004	(0.011)	6.98
Eurasian Former- USSR Countries	0.012	(0.014)	20.68

Note: Total observations is 5058. *, **, ***. Statistically significant at the 10%, 5% and 1% level, respectively.

VI. DISCUSSION AND FINAL REMARKS

The aim of the paper was to investigate the effect of gender ownership on technological innovation at the firm level and highlight the factors that explain the gender ownership gap in innovativeness for selected transition countries.

Employing a Probit model, we have first examined the factors that affect firm's innovation. Then, we have applied the extension of the Oaxaca-Blinder decomposition methodology developed by Powers et al. (2009) to investigate the gender innovation gap between firms with female owners and male-owned firms.

The main results of the innovation probability confirmed the role of gender ownership on the firm's propensity to innovate and recalled the relevance of the traditional factors on the decision to implement an innovation strategy. In fact, we find that the presence of females among the owners lead to an increase in innovation of more than 3% compared to only male-owned firms. Among the traditional assets, human capital, sources of knowledge and access to financial resources strongly impact the adoption of technological innovation.

Our findings also confirm that firms' external financial resources such as financial subsidies and the access to a line of credit are significant for the firm innovation activities. Furthermore, the firms that invest in R&D are more reactive than those which prefer not to allocate resources in R&D activities. At the same time, firms with external knowledge are more prone to adopt an innovation with respect to firms that have not acquired it. Finally, results for Country Regions are also interesting because, differently from European former-USSR Countries, the Eurasian former-USSR Countries present a significant and negative association with innovation. In this geographical area the long-run transition process has changed the innovation policies.

Employing the extension of Oaxaca-Blinder decomposition methodology, we find that the innovation disparity between firms with female among the owners and those that have only male owners is strongly significant and equal to 5.7%. This gap is mainly due to a 43% differences in endowment effects. The decomposition results confirm some results obtained by the probit model. The intangible assets as human capital and sources of knowledge are the main factors that affect the innovation gap between the two groups of firms. They represent 11.45% and 16.35% of endowment effect, respectively.

Among the factors that account for the human capital, the job-training activities contribute positively to this gap while the tertiary education negatively. Moving into the sources of knowledge, both R&D activities and external knowledge contribute positively to the innovation difference. Another characteristic that could explain the gap observed is the access to financial resources, namely the tangible assets of a firm. In detail, the access to subsidies widens the gap, conversely, the availability of credit line reduces it. Geographic factors and firm size explain another portion of the innovation gap.

From these results it seems that to reduce the gap between these two groups, firms are required to allocate more investments in human capital to improve the ability to innovate.

Therefore, firms should continuously promote training programs at all levels to increase worker participation in the strategic decisions of firms and should give priority to the recruitment of workers with a high level of education; in this way firms could build capabilities in support of innovation activity.

With regard to the sources of knowledge for innovation, firms should aim to improve internal knowledge to make better use of external knowledge. The acquisition of external knowledge could be useful to a firm if and only if it has an existing base of knowledge that enables it to use it. Hence, firms should implement/support policies and programs focus on developing an internal knowledge base for the optimal use of both types of knowledge.

Finally, the access to financial resources appears to be crucial to reduce disparities between firms to support innovation.

To conclude, although based on cross-sectional datasets, our analysis has highlighted a significant innovation gap between the two groups of firms in a sample of transition countries. Broadly speaking, some tangible and intangible assets appear to have triggered the technological innovation gap in the firms where a diversified gender composition of the ownership prevails. These are relevant results since they point out that in the period 2012-2014 the public decision-makers had a substantial role to finance firms with subsidies, and firms implemented investment in human capital and source of knowledge. These firms have improved their innovation performance by closing the innovation gap.

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Appendix

Table A.1: List of countries

Albania	Czech Republic	Kyrgyzstan	Russia
Armenia	Estonia	Lithuania	Serbia
Azerbaijan	North Macedonia	Latvia	Slovakia
Belarus	Georgia	Moldova	Slovenia
Bosnia-Herzegovina	Hungary	Montenegro	Tajikistan
Bulgaria	Kazakhstan	Poland	Ukraine
Croatia	Kosovo	Romania	Uzbekistan

Table A2: Description of variables

Variable	Description
Technological Innovation	1 if firm, in the last three years, has introduced a technological innovation, 0 otherwise
Firm Ownership	1 if the firm has female owners, 0 if firm ownership is exclusively male
Firm Dimension	
Small Firms	1 if a firm has <=19 employees
Medium Firms	2 if a firm has >=20 and <=99
Large Firms	3 if a firm has >=100
Firm Creation	
	1 Privatization of a state-owned firm 2 Originally private, from time of start up 3 Private subsidiary of a formerly state-owned firm 4 Joint venture with foreign partner(s) 5 State-owned firm
Affiliation	1 if a firm is part of larger firm, 0 otherwise
Female Workers	Percentage of the permanent full-time female workers (employees and managers) within the firm
Human Capital	
Education	Percentage of the permanent full-time workforce (employees and managers) holding a university degree
Training Programs	1 if a company, in the fiscal year, has formal training programs its employees, 0 otherwise
Experience Top Manager	Years of experience working in the sector of the top manager
Financial Resources	
Financial Subsidies	1 if a firm, in the last three years, has received any subsidies from the national, regional or local governments or European Union sources, 0 otherwise
Line of Credit	1 if a firm, in the fiscal year, have a line of credit or a loan from a financial institution, 0 otherwise
Research and Development	1 if a firm, during the last three years, has spent on R&D activities, either in-house or contracted with other companies, 0 otherwise
Knowledge	1 if a firm, during the last three years, has spent on the acquisition of external knowledge, 0 otherwise
Market Sales	
More National Sales	1 if a firm, in the fiscal year, sold its products more in national market
National and International Sales	2 if a firm, in the fiscal year, sold its products both in national and international market
More International Sales	3 if a firm, in the fiscal year, sold its products more in international market
Industry Sectors	
Low Tech	1 if a firm is a part of low tech sector
Medium Tech	2 if a firm is a part of medium tech sector
High Tech	3 if a firm is a part of high tech sector
Country Regions	
European Former-USSR Countries	1 for European Former-USSR Countries
Central European Countries	2 for Central European Countries
Former Yugoslavian Countries and Albania	3 for Former Yugoslavian Countries and Albania
Eurasian Former- USSR Countries	4 for Eurasian Former- USSR Countries