

Supplementary Appendix

A. Blinder-Oaxaca decomposition of non-linear regression models

This Supplementary Appendix illustrates the application of the Blinder-Oaxaca decomposition for the different non-linear regression models used in the empirical analysis.

S.1 Probit model with sample selection

The probit model with sample selection of the binary outcome y_i for the groups $g = (f, m)$ (i.e., female- and male-led firms) can be formally written as:

$$\begin{aligned} s_{ig} &= 1(\mathbf{z}'_{ig} \boldsymbol{\alpha}_g + u_{ig} > 0) \\ y_{ig} &= 1(\mathbf{x}'_{ig} \boldsymbol{\beta}_g + \varepsilon_{ig} > 0), \quad y_{ig} \text{ is observed only if } s_{ig} = 1 \\ \text{with: } \begin{pmatrix} u_{ig} \\ \varepsilon_{ig} \end{pmatrix} &\sim BVN \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho_{u\varepsilon_g} \\ \rho_{u\varepsilon_g} & 1 \end{pmatrix} \right] \end{aligned} \quad (\text{S.1})$$

$$i = 1, \dots, N_g, \quad N = \sum_g N_g$$

Within this framework, the conditional expectation of s_{ig} (evaluated at the parameter vector $\boldsymbol{\alpha}_g$) is equal to the conditional probability of $s_{ig} = 1$ and can be written as:

$$E(s_{ig} | \mathbf{z}_{ig}) = P(s_{ig} = 1 | \mathbf{z}_{ig}) = \Phi(\mathbf{z}'_{ig} \boldsymbol{\alpha}_g) \quad (\text{S.2})$$

while the conditional expectation of y_{ig} given that $s_{ig} = 1$ (evaluated at $\boldsymbol{\alpha}_g, \boldsymbol{\beta}_g$ and $\rho_{u\varepsilon_g}$) is equal to the conditional probability of $y_{ig} = 1$ given that $s_{ig} = 1$:

$$E_{\boldsymbol{\alpha}_g, \boldsymbol{\beta}_g, \rho_{u\varepsilon_g}}(y_{ig} | s_{ig} = 1, \mathbf{z}_{ig}, \mathbf{x}_{ig}) = P(y_{ig} = 1 | s_{ig} = 1, \mathbf{z}_{ig}, \mathbf{x}_{ig}) = \frac{\Phi_2(\mathbf{x}'_{ig} \boldsymbol{\beta}_g, \mathbf{z}'_{ig} \boldsymbol{\alpha}_g, \rho_{u\varepsilon_g})}{\Phi(\mathbf{z}'_{ig} \boldsymbol{\alpha}_g)} \quad (\text{S.3})$$

where $\Phi(\cdot)$ and $\Phi_2(\cdot)$ are the univariate and bivariate cumulative standard normal distributions, respectively. Based on the estimates of model parameters, the sample counterparts of the previous expressions can be computed as:

$$S(\hat{\boldsymbol{\alpha}}_g, \mathbf{z}_{ig}) = \frac{1}{N_g} \sum_{i=1}^{N_g} \Phi(\mathbf{z}'_{ig} \hat{\boldsymbol{\alpha}}_g) \quad (\text{S.4})$$

and

$$S(\hat{\boldsymbol{\alpha}}_g, \hat{\boldsymbol{\beta}}_g, \hat{\rho}_{u\varepsilon_g}, \mathbf{z}_{ig}, \mathbf{x}_{ig}) = \frac{1}{N_g} \sum_{i=1}^{N_g} \frac{\Phi_2(\mathbf{x}'_{ig} \hat{\boldsymbol{\beta}}_g, \mathbf{z}'_{ig} \hat{\boldsymbol{\alpha}}_g, \hat{\rho}_{u\varepsilon_g})}{\Phi(\mathbf{z}'_{ig} \hat{\boldsymbol{\alpha}}_g)} \quad (\text{S.5})$$

Following Aristei and Gallo (2016), after estimating the model separately for the two groups f and m and using group f as reference, the sample counterparts can be used to compute the generalised Blinder-Oaxaca (BO) decomposition equations for both the selection probability:

$$\hat{\Delta}^s = \left[\frac{1}{N_f} \sum_{i=1}^{N_f} \Phi(\mathbf{z}'_{if} \hat{\alpha}_f) - \frac{1}{N_m} \sum_{i=1}^{N_m} \Phi(\mathbf{z}'_{im} \hat{\alpha}_f) \right] + \left[\frac{1}{N_m} \sum_{i=1}^{N_m} \Phi(\mathbf{z}'_{im} \hat{\alpha}_f) - \frac{1}{N_m} \sum_{i=1}^{N_m} \Phi(\mathbf{z}'_{im} \hat{\alpha}_m) \right] \quad (\text{S.6})$$

and the conditional outcome probability:

$$\begin{aligned} \hat{\Delta}^{y/s} = & \left[\frac{1}{N_f} \sum_{i=1}^{N_f} \frac{\Phi_2(\mathbf{x}'_{if} \hat{\beta}_f, \mathbf{z}'_{if} \hat{\alpha}_f, \hat{\rho}_{u\varepsilon_f})}{\Phi(\mathbf{z}'_{if} \hat{\alpha}_f)} - \frac{1}{N_m} \sum_{i=1}^{N_m} \frac{\Phi_2(\mathbf{x}'_{im} \hat{\beta}_f, \mathbf{z}'_{im} \hat{\alpha}_f, \hat{\rho}_{u\varepsilon_f})}{\Phi(\mathbf{z}'_{im} \hat{\alpha}_f)} \right] \\ & + \left[\frac{1}{N_m} \sum_{i=1}^{N_m} \frac{\Phi_2(\mathbf{x}'_{im} \hat{\beta}_f, \mathbf{z}'_{im} \hat{\alpha}_f, \hat{\rho}_{u\varepsilon_f})}{\Phi(\mathbf{z}'_{im} \hat{\alpha}_f)} - \frac{1}{N_m} \sum_{i=1}^{N_m} \frac{\Phi_2(\mathbf{x}'_{im} \hat{\beta}_m, \mathbf{z}'_{im} \hat{\alpha}_m, \hat{\rho}_{u\varepsilon_m})}{\Phi(\mathbf{z}'_{im} \hat{\alpha}_m)} \right] \end{aligned} \quad (\text{S.7})$$

The first terms in (S.6) and (S.7) measure, respectively, the part of the average gap in the selection probability and in the conditional outcome probability due to differences in observable characteristics (*characteristics effect* or *explained part*). The second terms represent instead the part of the gap that cannot be explained by differences observable characteristics, but is due to differences in estimated coefficients (*coefficient effect* or *unexplained part*). In particular, decomposition (S.7) is used in our empirical analysis to decompose the average gender gaps in the conditional probabilities of credit rejection (i.e., $P(R_i = 1 | A_i = 1, \mathbf{z}_i, \mathbf{x}_i)$) and of credit discouragement (i.e., $P(D_i = 1 | N_i = 1, \mathbf{z}_i, \mathbf{w}_i)$). This allows us to investigate the role of observed and unobserved factors in determining differences in access to credit between female- and male-led firms and assess the presence of gender-based discrimination.

It is worth remarking that, when the error terms of the two equations are uncorrelated, the parameters of the outcome equation can be consistently estimated by means of a standard probit model for y_i on the subsample of observations for which $s_i = 1$. When $\rho_{u\varepsilon} = 0$, the decomposition equation for the conditional outcome probability is then given by:

$$\hat{\Delta}_{\rho_{u\varepsilon}=0}^{y/s} = \left[\frac{1}{N_f} \sum_{i=1}^{N_f} \Phi(\mathbf{x}'_{if} \hat{\beta}_f) - \frac{1}{N_m} \sum_{i=1}^{N_m} \Phi(\mathbf{x}'_{im} \hat{\beta}_f) \right] + \left[\frac{1}{N_m} \sum_{i=1}^{N_m} \Phi(\mathbf{x}'_{im} \hat{\beta}_f) - \frac{1}{N_m} \sum_{i=1}^{N_m} \Phi(\mathbf{x}'_{im} \hat{\beta}_m) \right] \quad (\text{S.8})$$

which corresponds to the BO decomposition for a probit model (estimated on the selected sample), discussed in Fairlie (2005) and Bauer and Sinning (2008).

S.2 Heckman sample selection model

The Heckman sample selection model of the outcome y_i for the groups $g = (f, m)$ can be written as:

$$\begin{aligned} s_{ig} &= 1(\mathbf{z}'_{ig} \alpha_g + u_{ig} > 0) \\ y_{ig} &= \mathbf{x}'_{ig} \beta_g + \varepsilon_{ig}, \quad y_{ig} \text{ is observed only if } s_{ig} = 1 \\ \text{with: } & \begin{pmatrix} u_{ig} \\ \varepsilon_{ig} \end{pmatrix} \sim BVN \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho_{u\varepsilon_g} \sigma_{\varepsilon_g} \\ \rho_{u\varepsilon_g} \sigma_{\varepsilon_g} & \sigma_{\varepsilon_g}^2 \end{pmatrix} \right] \end{aligned} \quad (\text{S.9})$$

$$i = 1, \dots, N_g, \quad N = \sum_g N_g$$

The conditional expectation of y_{ig} given that $s_{ig} = 1$ (evaluated at α_g, β_g and $\rho_{u\varepsilon_g}$) is:

$$E_{\alpha_g, \beta_g, \rho_{u_g}}(y_{ig} | s_{ig} = 1, \mathbf{z}_{ig}, \mathbf{x}_{ig}) = \mathbf{x}_{ig}' \beta_g + \rho_{u_g} \sigma_{\varepsilon_g} \frac{\phi(\mathbf{z}_{ig}' \alpha_g)}{\Phi(\mathbf{z}_{ig}' \alpha_g)} = \mathbf{x}_{ig}' \beta_g + \rho_{u_g} \sigma_{\varepsilon_g} \lambda(\mathbf{z}_{ig}' \alpha_g) \quad (\text{S.10})$$

where $\phi(\cdot)$ is the pdf of the standard normal and $\lambda(\cdot) = \phi(\cdot) / \Phi(\cdot)$ is the Inverse Mills Ratio. After estimating model parameters, the sample counterpart can be computed as:

$$S(\hat{\alpha}_g, \hat{\beta}_g, \hat{\rho}_{u_g}, \mathbf{z}_{ig}, \mathbf{x}_{ig}) = \sum_{i=1}^N \left[\mathbf{x}_{ig}' \hat{\beta}_g + \hat{\rho}_{u_g} \hat{\sigma}_{\varepsilon_g} \frac{\phi(\mathbf{z}_{ig}' \hat{\alpha}_g)}{\Phi(\mathbf{z}_{ig}' \hat{\alpha}_g)} \right] = \frac{1}{N_g} \sum_{i=1}^N \left[\mathbf{x}_{ig}' \hat{\beta}_g + \hat{\rho}_{u_g} \hat{\sigma}_{\varepsilon_g} \lambda(\mathbf{z}_{ig}' \hat{\alpha}_g) \right] \quad (\text{S.11})$$

In line with Aristei (2013), the BO decomposition equation of group differences in the conditional expectation of y_{ig} given that $s_{ig} = 1$ for the Heckman selection model can be then estimated as:

$$\begin{aligned} \hat{\Delta}^{y/s} = & \left[\frac{1}{N_f} \sum_{i=1}^{N_f} \left(\mathbf{x}_{if}' \hat{\beta}_f + \hat{\rho}_{u_f} \hat{\sigma}_{\varepsilon_f} \lambda(\mathbf{z}_{if}' \hat{\alpha}_f) \right) - \frac{1}{N_m} \sum_{i=1}^{N_m} \left(\mathbf{x}_{im}' \hat{\beta}_f + \hat{\rho}_{u_f} \hat{\sigma}_{\varepsilon_f} \lambda(\mathbf{z}_{im}' \hat{\alpha}_f) \right) \right] \\ & + \left[\frac{1}{N_m} \sum_{i=1}^{N_m} \left(\mathbf{x}_{im}' \hat{\beta}_f + \hat{\rho}_{u_f} \hat{\sigma}_{\varepsilon_f} \lambda(\mathbf{z}_{im}' \hat{\alpha}_f) \right) - \frac{1}{N_m} \sum_{i=1}^{N_m} \left(\mathbf{x}_{im}' \hat{\beta}_m + \hat{\rho}_{u_m} \hat{\sigma}_{\varepsilon_m} \lambda(\mathbf{z}_{im}' \hat{\alpha}_m) \right) \right] \end{aligned} \quad (\text{S.12})$$

where the first term measures the part of the average gap due to differences in observable characteristics and the second is the gap due to differences in estimated coefficients.¹ In our empirical analysis, decomposition (S.12) is used to decompose the mean difference in the interest rates charged on the most recent loan between female- and male-led firms.

Finally, it is worth remarking that, when $\rho_{u_g} = 0$, the parameters of the outcome equation can be consistently estimated by OLS estimation of a linear regression model of y_i on \mathbf{x}_i on the selected sample. In such cases, selectivity bias is not relevant and the generalised BO decomposition equation (S.12) reduces to the standard BO decomposition for linear regression:

$$\hat{\Delta}_{\rho_{u_g}=0}^{y/s} = \left[\frac{1}{N_f} \sum_{i=1}^{N_f} \mathbf{x}_{if}' \hat{\beta}_f - \frac{1}{N_m} \sum_{i=1}^{N_m} \mathbf{x}_{im}' \hat{\beta}_f \right] + \left[\frac{1}{N_m} \sum_{i=1}^{N_m} \mathbf{x}_{im}' \hat{\beta}_f - \frac{1}{N_m} \sum_{i=1}^{N_m} \mathbf{x}_{im}' \hat{\beta}_m \right] \quad (\text{S.13})$$

References

- Aristei, D., 2013. A Blinder–Oaxaca decomposition for double-hurdle models with an application to migrants' remittance behavior. *Applied Economics Letters* 20, 1665–1672.
- Bauer, T.K., and Sinning, M.G., 2008. An extension of the Blinder–Oaxaca decomposition to non-linear models. *Advances in Statistical Analysis*, 92, 197–206.
- Fairlie, R.W., 2005. An extension of the Blinder–Oaxaca decomposition technique to logit and probit models, *Journal of Economic and Social Measurement* 30, 305–316.
- Neuman, S., and Oaxaca, R.L., 2004. Wage decompositions with selectivity-corrected wage equations: A methodological note. *Journal of Economic Inequality* 2, 3–10.

¹ Group differences in the sample selection probability for the Heckman model can be decomposed using the BO decomposition equation (S.6). Moreover, see Neuman and Oaxaca (2004) for a discussion on alternative decomposition equations of differences in the conditional means for Heckman the sample selection model.

B. Additional Tables

Table S1 – The role of institutional and credit market factors on credit demand and rationing

	(1)		(2)		(3)	
	Applied	Rejected	Applied	Rejected	Applied	Rejected
FOF	-0.0173 (0.0132)	0.0508** (0.0228)				
FMF			-0.0241** (0.0120)	0.0366* (0.0215)		
FOF&FMF					-0.0350** (0.0150)	0.0754*** (0.0282)
Private credit to GDP	-0.0015*** (0.0005)	0.0024*** (0.0006)	-0.0014*** (0.0005)	0.0024*** (0.0006)	-0.0014*** (0.0005)	0.0023*** (0.0006)
Bank concentration	-0.0008* (0.0005)	0.0014*** (0.0005)	-0.0008* (0.0005)	0.0015*** (0.0005)	-0.0008* (0.0005)	0.0014*** (0.0005)
Non-performing loans	-0.0023* (0.0013)	0.0038** (0.0015)	-0.0023* (0.0013)	0.0039*** (0.0015)	-0.0023* (0.0013)	0.0038** (0.0015)
Bank Z-score	-0.0018*** (0.0007)	0.0002 (0.0009)	-0.0018*** (0.0007)	0.0002 (0.0009)	-0.0018*** (0.0007)	0.0003 (0.0009)
GDP growth rate	0.0004 (0.0010)	0.0034** (0.0015)	0.0005 (0.0010)	0.0034** (0.0015)	0.0004 (0.0010)	0.0035** (0.0015)
ρ	-0.7150*** (0.1458)		-0.7177*** (0.1449)		-0.7102*** (0.1489)	
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Country-group fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
N	8462		8462		8462	
Log Likelihood	-4725.02		-4724.32		-4721.59	

Notes: the Table reports estimated average marginal effects on the probability of applying for credit and on the conditional credit rationing probability (model (1)) using alternative gender definitions. All regressions include the firm-level variables included in the empirical specifications reported in Table 2 and sector and country-group fixed-effects. For brevity, we report the estimated marginal effects for the gender indicators and the country-level variables only. Robust standard errors, clustered on industry sectors within each country, are reported in parentheses below the estimates. Data on institutional characteristics are taken from the World Bank Global Financial Development Database and refer to 2011; country-level data are missing for Kosovo. *Private credit to GDP* is the percentage ratio of private credit by deposit money banks and other financial institutions to GDP; *Bank concentration* is the assets of three largest commercial banks as a percentage share of total commercial banking assets; *Non-performing loans* is the percentage ratio of defaulting loans to total gross loans; *Bank Z-score* is the average Z-score of country's banking system; *GDP growth rate* is the 2010-2011 annual growth rate of GDP per capita (thousands of constant 2005 US\$).

***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table S2 – The role of institutional and credit market factors on credit discouragement

	(1)		(2)		(3)	
	Need	Discouraged	Need	Discouraged	Need	Discouraged
FOF	0.0034 (0.0130)	0.0293* (0.0172)				
FMF			0.0006 (0.0121)	0.0529** (0.0214)		
FOF&FMF					-0.0013 (0.0134)	0.0644** (0.0268)
Private credit to GDP	-0.0005* (0.0003)	0.0020** (0.0009)	-0.0005* (0.0003)	0.0020** (0.0009)	-0.0005 (0.0003)	0.0020** (0.0009)
Bank concentration	0.0000 (0.0002)	-0.0002 (0.0008)	0.0000 (0.0002)	-0.0003 (0.0008)	0.0000 (0.0002)	-0.0003 (0.0008)
Non-performing loans	-0.0014** (0.0006)	0.0089*** (0.0024)	-0.0014** (0.0006)	0.0089*** (0.0024)	-0.0014** (0.0006)	0.0089*** (0.0024)
Bank Z-score	-0.0007** (0.0003)	-0.0004 (0.0014)	-0.0007** (0.0003)	-0.0004 (0.0015)	-0.0007** (0.0003)	-0.0004 (0.0014)
GDP growth rate	0.0000 (0.0005)	-0.0013 (0.0019)	0.0000 (0.0005)	-0.0013 (0.0019)	0.0000 (0.0005)	-0.0013 (0.0019)
ρ		0.0863 (0.1643)		0.0796 (0.1632)		0.0855 (0.1631)
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Country-group fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
N	8231		8231		8231	
Log Likelihood	-7325.21		-7322.40		-7322.67	

Notes: the Table reports estimated average marginal effects on the probability of needing credit and on the conditional probability of being credit discouraged (model (2)) using alternative gender definitions. All regressions include the firm-level variables included in the empirical specifications reported in Table 4 and sector and country-group fixed-effects. For brevity, we report the estimated marginal effects for the gender indicators and the country-level variables only. Robust standard errors, clustered on industry sectors within each country, are reported in parentheses below the estimates. Data on institutional characteristics are taken from the World Bank Global Financial Development Database and refer to 2011; country-level data are missing for Kosovo. *Private credit to GDP* is the percentage ratio of private credit by deposit money banks and other financial institutions to GDP; *Bank concentration* is the assets of three largest commercial banks as a percentage share of total commercial banking assets; *Non-performing loans* is the percentage ratio of defaulting loans to total gross loans; *Bank Z-score* is the average Z-score of country's banking system; *GDP growth rate* is the 2010-2011 annual growth rate of GDP per capita (thousands of constant 2005 US\$).

***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

Table S3 – The role of institutional and credit market factors on loan pricing conditions

	(1)		(2)		(3)	
	Have a loan	Interest rate	Have a loan	Interest rate	Have a loan	Interest rate
FOF	-0.0088 (0.0160)	0.8931*** (0.3421)				
FMF			-0.0259* (0.0150)	0.4598* (0.2754)		
FOF&FMF					-0.0261 (0.0178)	0.9419** (0.4186)
Private credit to GDP	-0.0004 (0.0017)	-0.0561** (0.0230)	-0.0004 (0.0017)	-0.0561** (0.0228)	-0.0004 (0.0017)	-0.0562** (0.0231)
Bank concentration	-0.0009 (0.0015)	-0.0017 (0.0191)	-0.0009 (0.0015)	-0.0016 (0.0190)	-0.0009 (0.0015)	-0.0020 (0.0191)
Non-performing loans	-0.0026 (0.0042)	0.0522 (0.0701)	-0.0026 (0.0042)	0.0540 (0.0698)	-0.0026 (0.0042)	0.0524 (0.0701)
Bank Z-score	-0.0003 (0.0021)	-0.0273 (0.0227)	-0.0003 (0.0021)	-0.0274 (0.0230)	-0.0003 (0.0021)	-0.0278 (0.0228)
GDP growth rate	-0.0047* (0.0027)	-0.0585 (0.0850)	-0.0046* (0.0027)	-0.0580 (0.0847)	-0.0047* (0.0027)	-0.0576 (0.0850)
ρ		-0.0675 (0.1292)		-0.0677 (0.1284)		-0.0678 (0.1286)
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Country-group fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
N	7610		7610		7610	
Log Likelihood	-10656.59		-10657.22		-10656.03	

Notes: the Table reports estimated average marginal effects on the probability of having a loan and on the conditional level of interest rate charged (model (3)) using alternative gender definitions. All regressions include the firm-level variables included in the empirical specifications reported in Table 6 and sector and country-group fixed-effects. For brevity, we report the estimated marginal effects for the gender indicators and the country-level variables only. Robust standard errors, clustered on industry sectors within each country, are reported in parentheses below the estimates. Data on institutional characteristics are taken from the World Bank Global Financial Development Database and refer to 2011; country-level data are missing for Kosovo. *Private credit to GDP* is the percentage ratio of private credit by deposit money banks and other financial institutions to GDP; *Bank concentration* is the assets of three largest commercial banks as a percentage share of total commercial banking assets; *Non-performing loans* is the percentage ratio of defaulting loans to total gross loans; *Bank Z-score* is the average Z-score of country's banking system; *GDP growth rate* is the 2010-2011 annual growth rate of GDP per capita (thousands of constant 2005 US\$).

***, ** and * denote significance at the 1, 5 and 10% levels, respectively.